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Evaluation of The LBJ School's Graduate-Level Math Readiness Program

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Evaluation of The LBJ School's Graduate-Level Math Readiness Program

by

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Report

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Executive Summary

Evaluation of The LBJ School's Graduate-Level Math Readiness Program

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The University of Texas at Austin, 2018

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Graduate-level policy students come to the discipline with a diverse spectrum of experience – some with a strong math background and others without. The main work of this study is to provide insights on the LBJ School of Public Affair's math readiness program for incoming masters students at the University of Texas at Austin.

In 2017, the LBJ School designed and implemented a new, three-phase math readiness program for incoming masters students. The three phases include: (1) summer self-study through online learning; (2) math validation exams and on-campus review sessions during orientation; and (3) ongoing math support during the fall semester. The central question of the report asks: is there evidence that the LBJ School's math readiness program drives student success outcomes?

To support this program evaluation, I performed a brief literature review and an environmental scan of peer institutions that was informed by interviews with faculty and staff at public policy schools across the country. Many schools are experimenting with

different combinations of online, in-person, targeted, or blanket approaches to math readiness over the summer months. The leadership at eight of the nine schools profiled in this study believe that math readiness is an important topic at their school and something worth dedicating resources towards.

This program evaluation takes a mixed methods approach to considering one cohort of incoming graduate students at the LBJ School in 2017. Data were collected from various sources, including admissions data, a post-orientation survey, and course grades submitted by faculty, among others. Qualitative results include survey feedback and participation records. Quantitative results include univariate analysis and OLS regression models with two dependent variables to represent student success in the quantitative core courses.

This study finds mixed evidence as to whether or not the LBJ School's math readiness program in 2017 impacted student outcomes in the short term. The univariate and descriptive analysis showed strong empirical evidence of associations between the Phase 1 and Phase 2 components of the math readiness program and student quantitative performance, most of which goes away in the final regression models. However, the study may be under-powered to detect significant associations between quantitative performance and certain components of the math readiness program, such as validation exam scores and the delta variables for students' self-assessed improvements over the summer.

Based on regression analysis, the strongest predictors of success in the quantitative core courses were factors determined well before students began the math readiness program: undergraduate GPA and quantitative GRE scores. Qualitatively, student participation and feedback strongly support the school continuing to provide math resources for incoming students and offer some ideas for program modifications moving forward.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

BACKGROUND

Many graduate-level public policy programs in the US require masters students to complete quantitative coursework in statistics and regression, economics, and finance as part of their degree requirements. Yet, policy students come to the discipline from a diverse spectrum of experience, including many with non-quantitative academic backgrounds, such as liberal arts or humanities studies, or students who are returning to graduate school after many years in the workforce. Policy schools value having a diversity of perspective and background among students, but keeping admissions requirements broad enough to capture a wide array of students can also create challenges. Because students with diverse backgrounds may lack adequate preparation and skillsets for the graduate-level policy curriculum, it is common practice at many policy schools to provide resources to help incoming graduate students prepare for their coursework prior to (or during) matriculation – covering topics such as government, political science, and mathematics.[1]

This report focuses on the "math readiness" element of matriculation programs, which can vary across different policy schools in availability, duration, obligation, format, and topics covered. The goal of math readiness programs is to improve student outcomes and ensure that students with less math experience can complete the required quantitative core courses on their way to graduation.

The main work of this study is to provide insights on one approach to math readiness for incoming masters students at the Lyndon B. Johnson School of Public Affairs at the University of Texas in Austin (the LBJ School). In 2017, the LBJ School designed

[1] Barton Wechsler and Dana Lee Baker, "Going Camping: A New Strategy for Preparing Academically Diverse Students," *Journal of Public Affairs Education* (National Association of Schools of Public Affairs and Administration (NASPAA)), accessed March 14, 2018, https://doi.org/10.2307/40215634.

and implemented a new, three-phase math readiness program for incoming masters students. The three phases include: (1) summer self-study through online learning; (2) math validation exams and on-campus review sessions during orientation; and (3) ongoing math support from a Math teaching assistant (Math TA) during the fall semester. Through data modeling and qualitative analysis, this report will evaluate the effectiveness of the LBJ School's new math readiness program. The central question I consider is: is there evidence that the LBJ School's math readiness program drives student success outcomes? In answering this question and the ensuing discussion, I aim to provide the LBJ School with an evaluation of the first year of its new math readiness program. To conclude, I will share recommendations for program improvements and highlight items for further consideration by the LBJ School.

SUPPORTING INFORMATION

To support this program evaluation study for the LBJ School and provide context for the analysis and recommendations, I looked at existing research on postsecondary math readiness and performed an environmental scan of other top-ranked policy schools. The environmental scan, crafted through informal interviews, brings to light some trends and tradeoffs for math readiness programs based on current practices at peer institutions.

Existing Research

I found this study to be operating in largely unchartered territory, as there is little (if any) existing scholarly research on graduate-level math readiness and none focusing on the public policy field specifically.[2] Based on my discussions with other public policy

[2] Organizations and journals consulted for this report include the Network of Schools of Public Policy, Affairs, and Administration (NASPAA), NASPAA's Journal of Public Affairs Education (JPAE), the Association for Public Policy Analysis and Management (APPAM), and ALEKs, among others.

schools around the US, a number of informal experiments and pilot programs exist, but no formal studies have been conducted to measure the efficacy or impact on student outcomes.

In 2004, Barton Wechsler and Dana Lee Baker examined common strategies employed by public policy schools to help adequately prepare incoming students with diverse backgrounds for success in their graduate programs.[3] Their study was not focused solely on math readiness. Wechsler and Baker's survey of sixty policy programs considered policy school "readiness" in a more comprehensive sense – including topics like American government, political science, and professionalism. Their study found "camping," or "systematic, intensive instruction outside the regular academic calendar," to be a promising practice that was not yet widely adopted at the time.[4] The LBJ School's month-long Camp LBJ was featured in the study as an innovative student preparation program alongside the Truman School's Camp Truman at the University of Missouri-Columbia. Overall, Wechsler and Baker concluded that camping provides "substantial benefits, but is not sufficient to provide all of the leveling required to ensure adequate foundational skills to allow for challenging instruction in core knowledge and competencies."[5]

Wechsler and Baker's 2004 study provides sound evidence that graduate school readiness has been a conversation at policy schools for nearly two decades – both for math and other subjects that are essential to success during the core curriculum. But no subsequent research has been published to assess any of these programs and the impact on student outcomes. In this report, I look to provide an abridged but updated overview of the math readiness conversation taking place at policy schools in 2018 and focus on a limited

[3] Wechsler and Baker.
[4] Ibid, 20.
[5] Ibid, 27.

evaluation of one graduate-level math readiness program to see what insights can be gained.

More robust research is available regarding collegiate math readiness at the undergraduate level. Scholarly research on math readiness interventions occurring pre-matriculation (such as summer bridge programs, boot camps, and brush-ups) indicates a short-term impact on student outcomes, mainly math placement, but no long-term impact on course completion rates.[6] This research, specifically, assessed pre-matriculation programs at community colleges, and it is debatable whether or not the findings are generalizable to our discussion of graduate-level policy programs.

Environmental Scan

To better contextualize this program evaluation for the LBJ School, it is helpful to understand what peer policy schools are doing in terms of math readiness for incoming masters students. An environmental scan, informed by interviews with relevant faculty and staff at other top ranked policy schools, can help us understand the state of math readiness across the broader policy school climate.

The environmental scan is based on a convenience sample of eight policy schools from the top fifteen rankings, plus the LBJ School, for a total of nine.[7] The sample was crafted to include a mix of policy schools – both public and private institutions offering a variety of policy degrees – that are arguably similar to the LBJ School, known for their rigorous quantitative curriculum, or both.[8] Table 1 provides a brief summary of the

[6] Michelle Hodara, "Improving Students' College Math Readiness: A Review of the Evidence on Postsecondary Interventions and Reforms A CAPSEE Working Paper," 2013, https://files.eric.ed.gov/fulltext/ED544544.pdf.

[7] "2017 Best Graduate Public Affairs Programs | US News Rankings," accessed March 15, 2018, https://www.usnews.com/best-graduate-schools/top-public-affairs-schools/public-affairs-rankings?int=a7cd09.

[8] The sample includes three private and six public institutions. Degrees represented include: Master of Public Policy (MPP), Master of Public Administration (MPA), Master of Public Affairs (MPAff), Master of

interviews and an overview of math readiness programs at each school. See Appendix A for a full, detailed discussion of math readiness programs at participating institutions.

These interviews with nine top-ranked graduate public policy programs across the country revealed that math readiness is indeed a key topic of discussion for faculty and administrators at most policy schools. Eight out of nine schools in the sample currently dedicate resources to math readiness but they vary in the types of programs and resources offered. The most common math readiness program was some form of "math camp," occurring in the weeks or days leading up to the start of the first semester of enrollment.

Table 1. Summary of Environmental Scan on Math Readiness Programs

Institution	Interviewee Role	Relevant Degrees	Admissions, Prerequisites, and Exams	Math Readiness Program	Other Notes
Carnegie Mellon University (Heinz College)	Associate Dean of the School of Public Policy and Management	MSPPM	Prerequisites in algebra, pre-calculus, probability, and statistics. Mandatory math assessment exam, must be passed before enrollment.	Four-week, in-person "Quantitative Skills Summer Program" for targeted students; considering transition to online only	Currently providing online self-study program for part-time MPM students; working to make this available to all MSPPM students as well.
Indiana University – Bloomington (SPEA)	Associate Director of Admissions and Student Services	MPAff	No required prerequisites. No formal assessment required.	One-week, in-person "Math Camp, optional for all students before orientation; regular and advanced sections.	Attending math camp may be required as a condition of admission for a select number of students.
New York University (Wagner)	Assistant Dean for Academic Programs	MPA	No required prerequisites nor GPA threshold for admissions. Do not require GRE.	Two Parts: (1) "Online Adaptive Learning Program" (ALEKS) and (2) in-person "Math Review Workshops" before and during the semester	Considering whether to make ALEKS required. Also provide additional in-semester resources like math tutor drop-in sessions.

Science in Public Policy Management (MSPPM), Master of Global Policy Students (MGPS), and a part-time Master of Public Management (MPM).

For further discussion of the differences and similarities between policy degrees, see: "MPA & MPP FAQ: NASPAA - The Global Standard in Public Service Education," accessed March 14, 2018, http://www.naspaa.org/students/faq/faq.asp.

Table 1. Summary of Environmental Scan on Math Readiness Programs (continued)

Institution	Interviewee Role	Relevant Degrees	Admissions, Prerequisites, and Exams	Math Readiness Program	Other Notes
University of California – Berkeley (Goldman)	Senior Assistant Dean of Academic Programs and Dean of Students	MPP and MPAff (for mid-career students)	Do not require prior quantitative training; but prior course work in introductory statistics or calculus, and economics is recommended.	Two-week, in-person "Math Camp" serves as optional "refresher" before students' first semester.	If students have not taken any of the recommended courses before applying, the school gives stronger weight to GRE scores.
University of Chicago (Harris)	Deputy Dean	MPP	No required quantitative prerequisites. Mandatory math exam during orientation. School identifies students to invite to pre-orientation math programs.	Two separate programs: (1) Three-week, in-person "Math Camp" for all enrolling students (optional) and (2) two-week "Jumpstart Program" by invitation only.	Provides online self-study resources over the summer (online lectures, videos, etc.) and provides a self-assessment exam to help students know how much preparation they need.
University of Georgia (SPIA)	MPA Program Director	MPA	No required quantitative prerequisites.	None.	Program leaders feel students do not require math preparation or help given the MPA curriculum.
University of Texas at Austin (LBJ School)	Associate Professor of Public Affairs	MPAff and MGPS	Prerequisites for calculus (MPAff) and statistics (MPAff and MGPS); can fulfill with previous coursework or by passing validation exam during orientation.	Three-Phase: (1) "Summer Self Study" using ALEKS and other resources, (2) in-person "Review Sessions" during orientation, and (3) ongoing in-semester support from Math TA. All optional.	Also offer a formal summer math course taught by an LBJ professor, tailored to concepts needed for success in core courses; completion does not count for degree requirement.
University of Michigan – Ann Arbor (Ford School)	Associate Dean for Academic Affairs	MPP	No required quantitative prerequisites.	Four-day "Math Camp" as a requirement during orientation. Summer reading lists are also provided (optional).	Added "Math Office Hours" in 2017 to help students with remedial math concepts. Hire tutors for any students in bottom quintile of quantitative courses.
University of Washington (Evans School)	Assistant Director of Student Services	MPA	No required quantitative prerequisites.	Three-day, in-person "Math Camp" before semester starts. Online math resources shared with all enrolling students. All optional.	Provide a set of math practice problems for students complete to self-assess need to attend math camp. Offer tutor-connecting service during semester.

Chapter 2: Overview of the LBJ School's Math Readiness Program

Starting in 2017, the LBJ School's leadership decided to move away from the school's longstanding, month-long Camp LBJ summer readiness program. In its place, they implemented a new three-phase math readiness program in conjunction with an updated orientation scheduled for the two weeks directly before the start of the semester.[9] The school's leadership cited accessibility and student socialization reasons as the main rationale for the change.

ADMISSIONS AND PREREQUISITES

Admissions and GRE Scores

While applicants to the LBJ School are required to submit GRE scores, the school has no hard or soft floor for quantitative GRE scores when considering candidates for admission. The faculty and leadership feel strongly about taking a holistic approach to admissions and not allowing a lack of quantitative aptitude to prevent exceptional students from joining the program. From the admissions website:

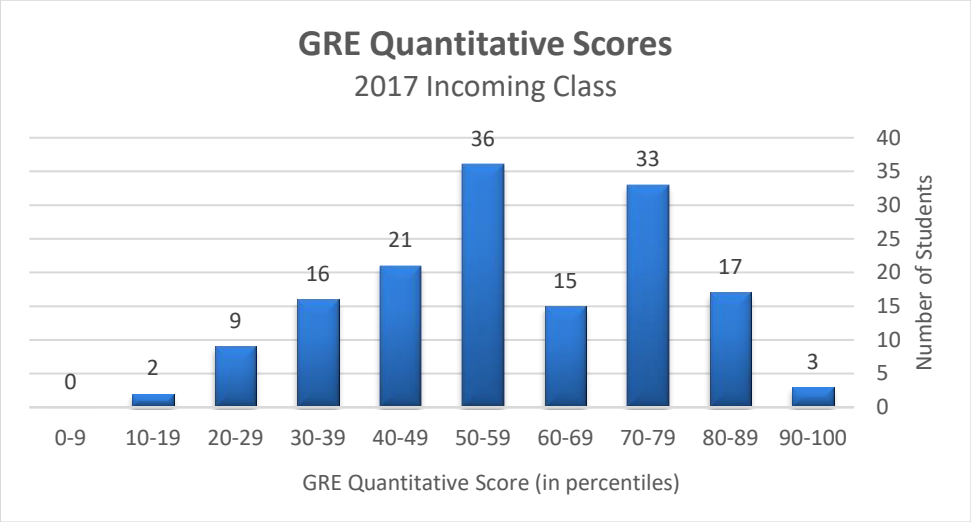
> "The LBJ School accepts applicants from a variety of undergraduate majors and seeks to form a class of students who bring a diverse set of experiences and perspectives to the school. Our students come from a variety of disciplines such as government, education, energy, engineering, business, health care, journalism and more."[10]

With this admissions scheme in mind, students in any given cohort at the LBJ School typically have a broad array of GRE quantitative scores. Figure 1 shows the distribution of the GRE quantitative scores, based on percentiles, for the 2017 incoming masters students at the LBJ School. If GRE scores are assumed to be a proxy for students'

[9] For a thorough profile of Camp LBJ and discussion of "camping" at public policy schools, see Wechsler and Baker's "Going Camping: A New Strategy for Preparing Academically Diverse Students."
[10] "Frequently Asked Questions | LBJ School of Public Affairs | The University of Texas at Austin," accessed March 20, 2018, https://lbj.utexas.edu/frequently-asked-questions.

math preparedness, it appears the LBJ School needs to do some leveling to get students ready to succeed in the quantitative core courses.

Figure 1. GRE Quantitative Scores – 2017 Incoming Class at the LBJ School



Math Prerequisites

Academic programs often use admissions prerequisites as a means of ensuring a standard baseline of knowledge and skills for all incoming students. In 2017, incoming Master of Public Affairs (MPAff) students at the LBJ School were required to have a demonstrated background in statistics, algebra, and differential calculus, with the goal of ensuring students were prepared to succeed in the core quantitative courses. Master of Global Policy Studies (MGPS) students at the LBJ School were required to demonstrate proficiency in statistics only, and had the same options as MPAff students for fulfilling the requirement. Students could fulfill their prerequisites through formal coursework or by passing the math validation exams given during orientation. Formal coursework options included undergraduate courses, local college courses, or the LBJ School's "Quantitative Foundations for Public Policy" (QFPP), a summer course taught by an LBJ professor but

not counting toward graduate degree completion. Students opting to take the validation exam(s) were strongly encouraged to study on their own over the summer. Separate exams were given for statistics and calculus.[11]

In 2017, the LBJ School encouraged all incoming students to take the validation exams regardless of their having completed prerequisite-fulfilling formal math coursework. The rationale was that the math courses students had completed outside of the LBJ School varied considerably in content, topics covered, applicability to public affairs, and time elapsed since. For these same reasons, the LBJ School plans to require all incoming students to take the math validation exams starting in the summer of 2018. Furthermore, starting in 2018, the math validation exams will be the only way for incoming students to fulfill their quantitative prerequisites, which will be changed to algebra and statistics for all students – both MPAff and MGPS candidates.

THE THREE PHASES

The 2017 math readiness program at the LBJ School was designed around three sequential phases occurring in the summer through the end of the fall semester: (1) summer self-study through online learning; (2) math assessment exams and on-campus review sessions during orientation; and (3) ongoing math support from a Math TA during the semester.

Other than the validation exams, the three phases of the program were voluntary and students could choose to participate in any combination of phases (or not at all).

The school collected quantitative and qualitative data to document student participation and feedback on each of the three phases of the math readiness program and

[11] The statistics exam was composed of two sections – one on statistics and one on probability. Similarly, he calculus exam was composed of two sections – one on calculus and one on algebra. Each section was graded separately, but students had to pass both sections of an exam for a passing grade.

at the conclusion of the Fall 2017 academic semester. Out of the incoming class of 153 MPAff students and Master of Global Policy Studies (MGPS) students, 114 participated in at least one phase of the math readiness program in 2017, for a participation rate of over 75 percent.[12]

Phase 1: Summer Self-Study

The first phase of the LBJ School's new program provided online resources to incoming students for independent self-study over the summer months before matriculation. The online resources were two-fold: access to an online assessment and learning system as well as suggested readings and practice problems from a textbook.

ALEKS Online Learning Tool

The LBJ School utilized a third-party tool, ALEKS®, to give students remote online access to self-paced math review.[13] ALEKS is one of several online learning tools using artificial intelligence (AI) to give students personalized and continuous feedback as they review and learn concepts through practice problems.[14] Students begin by taking an individual, adaptive assessment (the "knowledge check") through which ALEKS uncovers "the knowledge state of a student" and compiles a list of topics that he or she is "ready to learn."[15] After the initial assessment, students then enter "ALEKS Learning Mode" and are guided through different learning sequences where they attempt to solve problems,

[12] Participation numbers are based on best available individual data, including ALEKS participation data, student survey responses, and validation exam data. The LBJ School does not have individual data on in-semester TA review session attendance.
[13] ALEKS is a tool offered by the McGraw-Hill Education company. For more information, see: https://www.aleks.com/about_aleks/overview
[14] See companies providing competing adaptive learning tools:
Roger Riddell, "Adaptive Learning: The Best Approaches We've Seen so Far," *Education Drive*, 2013, www.educationdive.com/news/adaptive-learning-the-best-approaches-weve-seen-so-far/187875/.
[15] "What Makes ALEKS Unique," accessed March 13, 2018, https://www.aleks.com/about_aleks/What_Makes_ALEKS_Unique.pdf.

understand the explanations, and eventually master new topics.[16] Problems are not multiple choice, but require a "free response" from the student.

For 2017, the school's first year using ALEKS, the LBJ School used an off-the-shelf curriculum package, which covered both algebra and statistics.[17] Selected faculty and staff had access to each participating students' progress data. Around 50 percent of all incoming students used the tool at some point between May and August 2017, spending anywhere from 36 minutes to 35 hours using the tool and mastering some (or all) of the 224 topics available to LBJ students. On average, students progressed through 85 percent of the available material.

One of the drawbacks of ALEKS is that the curriculum does not cover calculus, which was a prerequisite for incoming MPAff students in 2017. In order to supplement this adaptive online learning module, the LBJ School provided separate materials to help students review calculus.

Textbook Readings and Problems

The LBJ School provided students with access to an online version of Frank Budnick's "Applied Mathematics for Business, Economics, and Social Sciences" for self-study of calculus, algebra and statistics.[18] Selected readings and practice problems from the textbook were available through an online portal for students to access at any point throughout the summer before matriculation.

The school was not able to collect electronic user data for students who used the Budnick textbook for math preparation. Student participation data and qualitative feedback

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[16] Ibid.

[17] To see a full list of the curriculum package, see: "ALEKS Essential Math Skills for Business," https://www.aleks.com/about_aleks/course_product_popup?cmscache=site_type:topic&site_type=business&topic=bmtbox.

[18] Frank S. Budnick, *Applied Mathematics for Business, Economics and the Social Sciences*, 4, revised ed. (McGraw-Hill, 1993).

were collected by survey at the conclusion of orientation. Based on the survey results, 36 percent of incoming students self-reported using the Budnick textbook.

Phase 2: Orientation Review Sessions and Exams

The LBJ School's Orientation in 2017 was held the two weeks directly preceding the start of the fall semester. Orientation was a mandatory event and nearly all of the 153 incoming students attended.[19] The second phase of the LBJ School's math readiness program came in the form of in-person review sessions and validation exams held during orientation.

Math Review Sessions

Over two weeks of orientation activities, incoming students were given the opportunity to attend four math review sessions led by an LBJ School PhD student. Each review session covered a different math topic – probability, statistics, algebra, and calculus. Attendance data were collected during each session and student participation data and feedback were collected by survey at the conclusion of orientation. Approximately 62 students attended at least one of the math review sessions during orientation for a participation rate of over 40 percent.

Math Validation Exams

As previously discussed, the LBJ School's math validation exams provide an opportunity for students to fulfill their math prerequisite or assess their preparedness and identify areas of weakness for further attention. As in years prior, there were separate exams for statistics and calculus in 2017.[20] The LBJ School provided two separate rounds

[19] According to the LBJ School's Office of Student Affairs and Admissions (OSAA), almost all incoming students participated in at least some part of Orientation in 2017. An official headcount was not available.
[20] For grading purposes, the statistics exam was broken down into two sections, one on probability and one on statistics. Similarly, the calculus exam was broken down into two sections, one on algebra and one on calculus.

of the exams for students – with the first round of exams given at the beginning of orientation, and another round of the same exams proctored again at the end of orientation (with the four math review sessions occurring in between). The second round of exams served primarily to give those who needed it a second chance to pass the exams and fulfill their prerequisites, after attending in-person review sessions and (perhaps) accessing the online math readiness resources.

A total of 79 students took some combination of the two exams in the first round of validation exams, but only 24 participated in the second round.

Phase 3: In-Semester Support

The third phase of the math readiness program occurred throughout the duration of the fall semester. The school hired a Math TA to hold weekly office hours and math workshops for all students. The Math TA, a second-year masters student at the LBJ School with previous experience teaching math, hosted ten hours of walk-in office hours every week (two hours each weekday) for students to drop in with math-related questions. It was made clear to students that no help would be given on course assignments, but the focus should be on more general math concepts and skills. Every Friday afternoon the Math TA hosted a two-hour workshop on a math topic planned and announced in advance.

While the LBJ School did not have a formal process for gathering data on the third phase of the program, I interviewed the math TA at the conclusion of the fall semester. His qualitative feedback is discussed later in this report.

OTHER MATH OPTIONS

The LBJ School also offers a formal summer math review course for incoming students, titled "Quantitative Foundations for Public Policy" (QFPP), taught by an LBJ School faculty member in June and July. Between 20-30 incoming students participate in

this optional course each summer. QFPP covers a review of algebra, probability, statistics, and differential calculus that is tailored towards the concepts and skills needed for success in the LBJ School's core curriculum. Up through 2017, students could use the course to cover their calculus and/or statistics prerequisite before enrollment.[21] QFPP requires tuition payment and does not count towards the students' masters degree completion. This summer math course has been offered for over two decades but is not accessible to all incoming students for financial and scheduling reasons. Classes are held in the evening for students who are working and living in Austin.

[21] Beginning in 2018, the QFPP course will still be offered, but will not fulfill the math prerequisites.

Chapter 3: Methods and Design

STUDY DESIGN

This program evaluation involves the observational study of one cohort of incoming students at the LBJ School (the Class of 2019) over an eight-month period spanning May to December 2017. Using a mixed methods approach, I explored the following three questions:

1. Can I assess the impact of the newly implemented three-phase approach to math readiness on student outcomes for matriculating masters students at the LBJ School?
2. What do the data tell us about the effectiveness of each of the three phases, independently and as a whole?
3. What insights can we derive from qualitative and quantitative findings to inform recommendations for the future of the LBJ School's math readiness program?

DATA OVERVIEW

This evaluation utilized a combined dataset of N = 153 masters students at the LBJ School who began their enrollment in the fall of 2017. This includes 96 MPAff students and 56 MGPS students. Given the disparate data sources used to create the dataset, some variables have a smaller sample size than N = 153.

Data Collection

Data on the student cohort were collected from multiple sources, including: the LBJ School's admissions data, a post-orientation student survey, administrative data from the ALEKS platform, math review session attendance records, validation exam scores, student grades for fall 2017 quantitative courses, and a qualitative interview with the LBJ School's Math TA.

Appendix D includes the math-readiness questions from the post-orientation student survey, which had 90 respondents. Appendix F details the interview questions for the LBJ School's Math TA, and Appendix G provides a summary of the interview with the Math TA for the fall of 2017.

All data were sanitized for identifying information before being added to the dataset to protect individual student identities.

Data Description

The dataset can be categorized into four subclasses:

- Outcome Data: grades and GPAs from the fall 2017 semester for quantitative core courses only.
- Pre-Enrollment Data: undergraduate information (GPA, major, minor), quantitative GRE scores, and LBJ School degree program (MPAff or MGPS).
- Demographic Data: gender, age, ethnicity (including a separate category for international students).
- Math Readiness Program Data: ALEKS usage, Budnick textbook usage, orientation math review session attendance, validation exam scores, registration for QFPP summer course, student math self-assessment survey results.

Table 2 provides an overview of the variables used in this study, including descriptions and data sources from which they were collected. Table 3 provides a descriptive summary of the same variables, including the overall means and a breakdown by degree program.

Table 2. Variable Description Table

Dependent Variables		
Variable	**Description**	**Data Source**
PROBATION	Indicates student has a GPA less than 3.0 across core quantitative courses in Fall 2017. That is, GPA < 3.0 is considered "probation" for this study (0=not on probation)	Student grades collected from LBJ School Faculty N=140
QGPA	Student GPA across core quantitative courses in Fall 2017	Student grades collected from LBJ School Faculty N=140
Explanatory Variables		
Pre-Enrollment Data		
Variable	**Description**	**Data Source**
UG GPA	Undergraduate GPA	Admissions data N=153
MAJ MIN	Indicates student with a math-related major *or* minor in undergrad (0=neither)	Post-Orientation Student Survey N=90
QGRE	Student quantitative GRE score, based on percentile	Admissions data N=153
MPAFF	Student is in the MPAff Program (0=MGPS)	Admissions data N=153
Demographic Data		
Variable	**Description**	**Data Source**
FEMALE	Student is female (0=male)	Admissions Data N=153
AGE	Indicates students age upon matriculation to the LBJ School	Admissions Data N=153
ETHNICITY	Indicates student ethnicity from subcategories: 1=White only, 2=Hispanic, 3=Black, 4=Asian, 5=International student, 6=Unknown	Admissions Data N=153
Math Readiness Program Data		
Variable	**Description**	**Data Source**
USE ALEKS	Student used ALEKS online platform for any length of time > 0 minutes (0=did not use ALEKS)	Data collected from ALEKS tool, cross-referenced with admissions data N=153
TIME IN ALEKS	Measure of cumulative time a student spent on the ALEKS platform (measured in hours)	Data collected from ALEKS tool, cross-referenced with admissions data N = 153

Table 2. Variable Description Table (continued)

USE BUDNICK	Indicates student reported he or she used the Budnick textbook for self-study (0=did not report use)	Post-Orientation Student Survey N=90
MATH REVIEW	Indicates student attended at least 1 math review session during orientation (0=attended none)	Based on attendance records recorded by LBJ staff N= 153
WKSHP STATS	Student attended statistics math review session during orientation (0=did not attend)	Based on attendance records recorded by LBJ staff N=153
WKSHP PROB	Student attended probability math review session during orientation (0=did not attend)	Based on attendance records recorded by LBJ staff N=153
WKSHP ALG	Student attended algebra math review session during orientation (0=did not attend)	Based on attendance records recorded by LBJ staff N=153
WKSHP CALC	Student attended calculus math review session during orientation (0=did not attend)	Based on attendance records recorded by LBJ staff N=153
VEXAM STATS	Student score on the statistics section of the first-round validation exam, measured in percentage	Validation exam scores collected by LBJ staff N=153
VEXAM PROB	Student score on the probability section of the first-round validation exam, measured in percentage	Validation exam scores collected by LBJ staff N=153
VEXAM ALG	Student score on the algebra section of the first-round validation exam, measured in percentage	Validation exam scores collected by LBJ staff N=153
VEXAM CALC	Student score on the calculus section of the first-round validation exam, measured in percentage	Validation exam scores collected by LBJ staff N=153
QFPP	Student took formal summer math review course at the LBJ School during June-July to cover math prerequisite (0=did not take QFPP)	Admissions Data N=153
DELTA STATS	Student self-reported change in math proficiency in statistics from the beginning of summer to end of orientation	Post-Orientation Student Survey N=90
DELTA PROB	Student self-reported change in math proficiency in probability from the beginning of summer to end of orientation	Post-Orientation Student Survey N=90
DELTA ALG	Student self-reported change in math proficiency in algebra from the beginning of summer to end of orientation	Post-Orientation Student Survey N=90
DELTA CALC	Student self-reported change in math proficiency in calculus from the beginning of summer to end of orientation	Post-Orientation Student Survey N=90

Table 2. Variable Description Table (continued)

Teacher Dummy Variables		
Variable	**Description**	**Data Source**
LENTZ AM	Student took Analytical Methods course with Dr. Lentz in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140
LUBY PFM	Student took Public Financial Management course with Dr. Luby in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140
MEYER IEM	Student took Introduction to Empirical Methods course with Professor Meyer in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140
OLMS MICRO	Student took Microeconomics course with Dr. Olmstead in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140
SPEL AMICRO	Student took Applied Microeconomics course with Dr. Spelman in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140
WILSON IEM	Student took Introduction to Empirical Methods course with Dr. Wilson in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140
WILSON APE	Student took Advanced Policy Economics course with Dr. Wilson in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140
WONG IEM	Student took Introduction to Empirical Methods course with Dr. Wong in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140
WONG AMICRO	Student took Applied Microeconomics course with Dr. Wong in Fall 2017 (0=did not take course)	Student grades collected from LBJ School Faculty N=140

Table 3. Descriptive Summary Table

Descriptive Summary Table			
	Overall	**MPAff**	**MGPS**
N	**152**	**96**	**56**
Dependent Variables			
Means			
Variable	**Overall**	**MPAff**	**MGPS**
PROBATION	0.210	0.198	0.230
QGPA	3.35	3.34	3.37

Table 3. Descriptive Summary Table (continued)

Explanatory Variables			
Pre-Enrollment Data Means			
Variable	**Overall**	**MPAff**	**MGPS**
UG GPA	3.62	3.60	3.64
MAJ MIN	0.313	0.321	0.303
QGRE	58.3	58.8	57.5
Demographic Data Means			
Variable	**Overall**	**MPAff**	**MGPS**
FEMALE	0.640	0.615	0.685
AGE	25.9	25.8	26.1
ETHNICITY			
1=White only	0.664	0.646	0.696
2=Hispanic	0.151	0.177	0.107
3=Black	0.013	0.021	0.000
4=Asian	0.059	0.073	0.036
5=International	0.072	0.042	0.125
6=Unknown	0.039	0.042	0.036
Math Readiness Program Data Means			
Variable	**Overall**	**MPAff**	**MGPS**
USE ALEKS	0.487	0.427	0.589
TIME IN ALEKS	6.53	6.00	7.42
USE BUDNICK	0.609	0.604	0.618
MATH REVIEW	0.322	0.396	0.196
WKSHP STATS	0.257	0.302	0.179
WKSHP PROB	0.349	0.427	0.214
WKSHP ALG	0.158	0.208	0.071
WKSHP CALC	0.257	0.365	0.071
VEXAM STATS	90.5	90.8	90.1
VEXAM PROB	78.4	78.5	78.3
VEXAM ALG	90.2	91.1	87.3
VEXAM CALC	58.3	62.7	45.4
QFPP	0.145	0.198	0.054
DELTA STATS	0.758	0.717	0.824

Table 3. Descriptive Summary Table (continued)

DELTA PROB	0.667	0.585	0.794
DELTA ALG	0.368	0.358	0.382
DELTA CALC	0.920	1.090	0.647
Teacher Dummy Variables Means			
Variable	**Overall**	**MPAff**	**MGPS**
LENTZ AM	0.336	0.000	0.911
LUBY PFM	0.283	0.438	0.018
MEYER IEM	0.184	0.292	0.000
OLMS MICRO	0.388	0.156	0.786
SPEL AMICRO	0.158	0.240	0.018
WILSON IEM	0.184	0.292	0.000
WILSON APE[22]	0.007	0.010	0.000
WONG IEM	0.118	0.188	0.000
WONG AMICRO	0.079	0.125	0.000

In the student survey that was distributed after orientation, each student was asked to assess his or her level of math proficiency on each of four math topics at the beginning of summer and then again at the end of orientation based on the same rating scale from one to five (one being "do not know it at all," and five being "could teach the subject"). See Appendix D for a copy of the survey, including the self-assessment questions and complete scale.

For the purpose of this study, I used this self-assessment data to create four "delta" variables, each indicating the student's self-perceived change in proficiency level over the course of the summer – one variable for each relevant math subject (probability, statistics, algebra, and calculus). Focusing on the students' change in rating over the summer, as opposed to simply their final rating at the end of orientation, is meant to capture their

[22] Advanced Policy Economics (APE) is an advanced core course that most students take after they complete their Microeconomics course, which is a prerequisite. In other words, there are not many first-year students who take APE in the fall semester.

improvement over the summer months. Using the delta variables also helps eliminate some of the natural bias that occurs from survey respondents interpreting and using rating scales differently. Appendix E shows four tables depicting students' self-assessment on each math subject at the beginning of summer (on the vertical axis) compared to the end of summer (on the horizontal axis), as well as four distribution tables with the breakdown of delta variables for students who used the ALEKS platform or the Budnick textbook compared to those who did not.

ANALYSIS

Using the above data, I performed multiple analyses that, combined, constitute the foundation for the program evaluation.

First, I started with a simple analysis of univariate statistics, looking at the probation dependent variable compared to the explanatory variables in the dataset. This basic analysis does not deal with causes or relationships but describes the data and allowed me to identify trends to look for during further analysis.

Second, I compiled comparative tables for the delta variables to summarize the changes in students' self-perceived math knowledge over the timeframe of the math readiness program (see Appendix E). For additional analysis of the self-assessment data, I also looked at the distributions of the deltas for each of the four math subjects broken up by students who used the summer self-study resources and those who did not.

Third, I calculated correlations between validation exam scores and the quantitative GPA dependent variable to see if there was any relationship between success on the validation exams and success in the classroom during the semester.

To conclude my quantitative exploration of the impact of the math readiness program on student success in the quantitative core courses, I ran a series of regression

models to further explore the relationships between the dependent and explanatory variables, while controlling for other variables.

Models

I developed a series of ordinary least squares (OLS) regression models based on the different subclasses of explanatory variables in the dataset.

The goal of the models was to statistically analyze various components of the math readiness program, controlling for other relevant factors, to see if they were predictive of student outcome variables. Given the timeline of this study, I created two outcome variables based on students' grades in the quantitative core courses during the Fall 2017 semester.

First, I compiled the students' letter grades from all the quantitative core courses offered during the semester and created a "quantitative GPA" for each student to represent his or her success in the quantitative core curriculum.[23] This continuous variable is named QGPA.

Second, I created an outcome variable to indicate whether a student was on academic "probation" at the end of the Fall 2017 semester based on their grades in quantitative core courses. This binary variable indicates that a student's GPA for quantitative courses (only) fell below the probationary threshold of 3.00 and is named PROBATION. It is important to note that this variable is derived from a GPA I created based only on quantitative courses for the purposes of this study and is not a representation of students who were actually on academic probation at the LBJ School, as their grades in non-quantitative courses may have brought their overall GPA to 3.00 or above.

[23] Letter grades were converted to GPA using the standard University of Texas at Austin grading scale. See: https://registrar.utexas.edu/students/grades

Using these two dependent variables, I formed a series of ordinary least squares (OLS) regression models with different subsets of the variables described in Table 2. The results and findings from these models will be discussed in subsequent chapters.

There are a number of explanatory variables that I initially wanted to include in the final regression models but ended up excluding due to incomplete data. Including these variables would have reduced the sample size for the model well below an N that I felt comfortable working with for analyses and findings. This applies to variables such as USE BUDNICK, the VEXAM variables, and the DELTA variables (described in Table 2). When running exploratory regression models that include these variables (N=45), the only statistically significant explanatory variables were consistent with those that resulted from the final models (with N=128). The USE BUDNICK, VEXAM, and DELTA variables were not found to have a statistically significant impact on the student outcome variables in the exploratory models.

Chapter 4: Results

QUALITATIVE RESULTS

Students provided qualitative feedback on different components of the LBJ School's math readiness program through a voluntary electronic survey distributed after orientation. Ninety students completed the survey, for a response rate of nearly 60 percent of all incoming students. The following sections of this report highlight summaries of the student feedback collected about the different phases of the math readiness program.

Phase 1: Summer Self-Study

ALEKS Feedback

Approximately 60 percent of survey respondents used ALEKS prior to matriculation to practice algebra, probability, and statistics problems (53 out of 90 respondents). Out of survey respondents who used ALEKS, 100 percent would recommend it to next year's students.

As shown in Table 4, the top reasons students liked the online learning platform include how easy it was for them to access and use the tool, taking the assessment to help them understand what they needed to learn, and the well-illustrated explanations. Students wished ALEKS would have covered calculus content in addition to algebra, probability, and statistics. Some students also thought the platform needed more variation in its practice problems, which they found repetitive. See more feedback on what students did not like about ALEKS in Table 5.

Table 4. Survey Response Summary: "What did you like?" about ALEKS

"What I liked" about ALEKS	No. of Responses
Easy to use/user friendly	15
The assessment/it helped me understand what I don't know	15
Good explanations	13
Breadth of material/comprehensiveness	5
Self-paced/flexible schedule	4
Fun/engaging	3
The pie chart	3
Immediate Feedback	2
Ability to track my progress	2

Table 5. Survey Response Summary: "What did you not like?" about ALEKS

"What I did not like" about ALEKS	No. of Responses
I wish it included calculus	12
Practice problems were repetitive	7
Wish it had more teaching material/hard to supplement elsewhere	5
Very time intensive	4
I liked it all	4
Explanations were lacking	3
Wish it allowed me to continue testing after completion	3
Some materials were too basic	2
Gave me false confidence because materials didn't align with curriculum	2
I'm not much of a digital learner	1

Budnick Textbook Feedback

Approximately 61 percent of survey respondents used the Budnick textbook during the summer before matriculation to review calculus concepts and practice problems (55 out of 90 respondents). Out of survey respondents who used the textbook, 64 percent would recommend it to next year's students. Six respondents qualified their recommendations with the suggestion that Budnick be supplemented by videos or other digital learning resources.

Many students appear to have liked the practice problems and examples provided in the Budnick textbook and found the content to be easy to understand. However, some students found the content to be too dense and not engaging enough for their preference. See the full summaries of positive and negative feedback about the Budnick textbook in Tables 6 and 7, below.

Table 6. Survey Response Summary: "What did you like?" about Budnick

"What I liked" about the Budnick Textbook	**No. of Responses**
Good examples and practice problems	18
Straightforward/easy to comprehend	11
Comprehensive	6
Good review	4
Step-by-step guides/materials well taught	3
Liked the focused study materials for upcoming classes	3
Self-taught nature	1
Better than ALEKS at explaining concepts	1
I liked very little	1

Table 7. Survey Response Summary: "What did you not like?" about Budnick

"What I did not like" about the Budnick Textbook	**No. of Responses**
Dense content	8
Not engaging/visual	7
Hard not to have someone to consult when not grasping a concept	5
Not enough coverage of important/tested concepts	4
Nothing	4
Needed clearer problem sets and answers	3
Hard to pace myself/weird transition after using ALEKS	2
Hard to consult other online resources to fill in gaps	2

Out of 55 survey respondents who used the Budnick textbook, 40 also used the ALEKS platform. Thus, over 70 percent of survey respondents who used at least one of the two math resources used both the Budnick textbook and the ALEKS platform. Some

students compared the two different resources when providing feedback – some preferring a platform like ALEKS that provides guidance and immediate feedback, others preferring the explanations and applicable examples from the Budnick textbook.

Phase 2: Orientation Review Sessions and Exams

Orientation Review Sessions Feedback

Nearly 50 percent of survey respondents attended at least one of the four math review sessions during orientation (44 out of 90 respondents). In addition to the survey responses summarized below, the most common student suggestion to improve the review sessions was to split the students into two groups based on existing math knowledge.

Overall, the students were favorable toward the PhD candidate who taught the review sessions and found him to be an engaging instructor. Students also appreciated that the review sessions were focused on the material they needed to know to be successful on the validation exams and their quantitative courses in the fall semester. Table 8 provides additional feedback on what students liked about the math review sessions.

As shown in Table 9, the top two things students did not like about the review sessions were the inability to go beyond the basic concepts and the vast amount of information covered in a relatively short amount of time.

Table 8. Survey Response Summary: "What did you like?" about Orientation Math Review Sessions

"What I liked" about Orientation Math Review Sessions Survey Responses	**No. of Responses**
Instructor was engaging/approachable	17
It was focused only on what we needed to review	9
Good explanations/sample problems	6
Helpful to have life instruction and be in a classroom	6
Ability to ask questions	2
Helped me do better on the validation exam retest	1

Table 9. Survey Response Summary: "What did you not like?" about Orientation Math Review Sessions

"What I did not like" about Orientation Math Review Sessions Survey Responses	**No. of Responses**
It was too basic/we could not go very deep	8
A lot of information in a short amount of time	5
Too participatory and confusing	4
Students had varying levels of understanding	3
Nothing	3
Wanted more technical info, less theory	2
Wanted more about how this math relates to policy	1
Moved too slow	1
Should have been more comprehensive	1

There was no qualitative feedback collected on the validation exam scores, which comprised the other part of Phase 2 of the math readiness program.

Phase 3: In-Semester Support

The data for Phase 3 of the math readiness program are limited to the attendance records for the weekly review session and drop-in tutoring hours, as shown in Table 10. The maximum total weekly attendance was nine students.

Table 10. LBJ School Math TA Topics and Attendance Records for Fall 2017

		No. of Attendees	
Week	**Review Session Topic**	**Review Session**	**Tutoring Hours**
1	Functions	8	1
2	Equations & Simultaneous Equations	3	2
3	Mechanics of Differential Calculus	5	2
4	Applications of Differential Calculus	2	3
5	Basic Probabilities	2	1
6	Probability Distributions	3	2
7	Tables of Expected Values	1	0
8	-	-	1
9	Building Mathematical Models	2	1
10	Linear Regression	1	2
11	Linear Programming	2	2
12	Hypothesis Testing	1	3
13	Finals Review	*Unknown*	*Unknown*

Appendix G provides a summary of the Math TA's feedback for Fall 2017, including his reflections on his experience serving in the role and his recommended changes for the future of the program. There was no student feedback collected on the in-semester support offered by the Math TA.

QUANTITATIVE RESULTS

Univariate Analysis

To begin my quantitative analysis, I looked at univariate associations between the "probation" outcome variable and various explanatory variables to obtain a better understanding of the underlying data.

Tables 11, 12, and 13 show descriptive statistics grouped by the three data subclasses of pre-enrollment data, demographics, and math readiness program. All observations from these tables are simple (unadjusted) associations because I am not controlling for other factors as in the regression models.

Table 11. Descriptive Statistics for Pre-Enrollment Data with PROBATION

PRE-ENROLLMENT DATA	*Probation?*			*%*
	No	**Yes**	**Total**	**Probation**
Total Dataset	**109**	**29**	**138**	21%
Degree Program				
MPAff	69	17	**86**	20%
MGPS	40	12	**52**	23%
Quantitative GRE Percentile				
90-100	3	0	**3**	0%
80-89	14	0	**14**	0%
70-79	26	5	**31**	16%
60-69	11	4	**15**	27%
50-59	32	2	**34**	6%
40-49	13	5	**18**	28%
30-39	6	7	**13**	54%
20-29	2	6	**8**	75%
10-19	2	0	**2**	0%

Table 11. Descriptive Statistics for Pre-Enrollment Data with PROBATION (continued)

Undergraduate GPA				
4.00	4	3	**7**	43%
3.80 - 3.99	32	1	**33**	3%
3.60 - 3.79	27	9	**36**	25%
3.40 - 3.59	22	4	**26**	15%
3.20 - 3.39	10	5	**15**	33%
3.00 - 3.19	6	5	**11**	45%
2.80 - 2.99	0	1	**1**	100%

As shown in Table 11, the spread of students on quantitative probation is proportionate between the two different degree programs at the LBJ School. It appears there is a general association for students with lower undergraduate GPAs or quantitative GRE scores to be more likely to be on probation. One anomaly is the large proportion of students with a 4.0 undergraduate GPA who ended up on quantitative probation after their first semester at the LBJ School.

Table 12. Descriptive Statistics for Demographic Data with PROBATION

DEMOGRAPHIC DATA	***Probation?***			***%***
	No	**Yes**	**Total**	**Probation**
Gender				
Female	68	19	**87**	22%
Male	39	10	**49**	20%
Ethnicity/International				
White only	72	20	**92**	22%
Hispanic	16	6	**22**	27%
Other	7	0	**7**	0%
International	8	2	**10**	20%
Age (at enrollment)				
20-22	19	8	**27**	30%
23-25	40	7	**47**	15%
26-28	31	10	**41**	24%
29-31	10	3	**13**	23%
32+	9	1	**10**	10%

Table 12 shows no observable associations for any specific demographic groups being more likely to be on quantitative probation.

Table 13. Descriptive Statistics for Math Readiness Data with PROBATION

MATH READINESS DATA	*Probation?*			*%*
	No	**Yes**	**Total**	**Probation**
ALEKS Usage				
Used ALEKS	60	9	**69**	13%
Didn't use ALEKS	51	20	**71**	28%
Orientation Math Review Sessions				
1+ Attended	56	6	**62**	10%
No attendance	55	23	**78**	29%
QFPP Summer Course				
Took QFPP	10	12	**22**	55%
Didn't take QFPP	101	17	**118**	14%
Validation Exam Scores (in percentages)				
Statistics Section				
90-100	41	3	**44**	7%
80-89	14	4	**18**	22%
79 and below	4	3	**7**	43%
Probability Section				
90-100	21	2	**23**	9%
80-89	14	4	**18**	22%
70-79	6	2	**8**	25%
60-69	10	1	**11**	9%
59 and below	8	1	**9**	11%
Algebra Section				
90-100	35	1	**36**	3%
80-89	12	5	**17**	29%
79 and below	5	2	**7**	29%
Calculus Section				
90-100	15	0	**15**	0%
80-89	10	1	**11**	9%
70-79	1	0	**1**	0%
60-69	4	0	**4**	0%
59 and below	22	7	**29**	24%

As seen in Table 13, it appears that students who used the ALEKS platform to review math concepts over the summer or attended at least one math review session during orientation are less associated with being on probation. This basic comparison also shows that students who took the QFPP course over the summer were more likely to be on probation than those who did not and students who did poorly on the validation exams were somewhat more associated with quantitative probation than those who scored 90 or above on any given section.

Table 14 shows descriptive statistics for data collected from the post-orientation survey (with a smaller sample size).

Table 14. Descriptive Statistics for Survey Data with PROBATION

SURVEY DATA ONLY	***Probation?***			***%***
	No	**Yes**	**Total**	**Probation**
Total Respondents	**69**	**15**	**84**	18%
Budnick				
Used Budnick	47	4	**51**	8%
Did not use Budnick	22	11	**33**	33%
Undergrad Major/Minor				
Math-related	22	5	**27**	19%
Not math-related	47	10	**57**	18%
Student Math Self-Assessment[24]				
Change in Probability				
0	31	11	**42**	26%
1	23	4	**27**	15%
2	13	0	**13**	0%
3	1	0	**1**	0%

[24] Students' math self-assessment represents data from the post-orientation survey where students were asked to rate their knowledge on each of the four math subjects at the beginning and again at the end of summer. The change shown here represents the difference in the students' rating at the end of orientation compared to the beginning of summer. These data points correspond with the DELTA variables described in Table 2.

Table 14. Descriptive Statistics for Survey Data with PROBATION (continued)

Change in Statistics				
0	28	7	**35**	20%
1	29	8	**37**	22%
2	11	0	**11**	0%
3	1	0	**1**	0%
Change in Algebra				
0	46	11	**57**	19%
1	20	4	**24**	17%
2	3	0	**3**	0%
Change in Calculus				
0	25	7	**32**	22%
1	26	6	**32**	19%
2	16	1	**17**	6%
3	2	1	**3**	33%

While there appears to be no association between having majored or minored in a math-related subject in undergrad, the survey data shared in Table 14 indicate that students who used the Budnick textbook for self-study were less likely to be on probation than those who did not.

There seems to be a negative correlation between changes in students self-assessed improvement over the summer and the likelihood that they ended up on quantitative probation. Appendix E provides a deeper look at the changes in self-assessment from the beginning to end of the summer and shows that students who used ALEKS or the Budnick textbook self-reported more knowledge gain than those who did not use the self-study resources. However, it is unclear whether this gain in knowledge over the summer translated to better quantitative grades in the fall semester.

Lastly, because the validation exams will be required for all incoming LBJ School students starting in 2018, I wanted to see how validation exam scores correlated with the

QGPA dependent variable. Table 15 details these correlations for the four topical sections of the first round of validation exam scores.

Table 15. Validation Exam Score Correlations with QGPA

	Correlation with QGPA
Statistics Score VEXAM STATS	0.294
Probability Score VEXAM PROB	0.323
Algebra Score VEXAM ALG	0.489
Calculus Score VEXAM CALC	0.427

It appears aptitude in algebra and calculus, as measured by the validation exams at the beginning of orientation, were most strongly correlated with academic success in the quantitative core courses.

Regression Analysis

After looking at the univariate associations, I developed a series of OLS regression models based on the different subclasses of explanatory variables in the dataset. Table 16 shows the resulting beta coefficients and fit statistics from four statistical models assessing the impact of the explanatory variables on the likelihood that a student would be on quantitative probation.

Table 16. Results from Linear Probability Regression Models with PROBATION

REGRESSION OUTPUT ***PROBATION Dependent Variable (1=On Probation, 0=Not)***				
	Betas			
Model	**(1)**	**(2)**	**(3)**	**(4)**
N	136	128	128	128
Demographic				
FEMALE	.0150	.0187	.0784	.1156
	(.846)	(.805)	(.285)	(.118)
AGE	-.0032	-.0074	-.0001	.0032
	(.748)	(.442)	(.989)	(.720)
ETHNICITY				
1 = White only				
2 = Hispanic	.0528	-.0510	.0673	.0107
	(.596)	(.590)	(.456)	(.907)
3 = Black	-.2175	-.3600	-.2901	-.2835
	(.471)	(.199)	(.269)	(.273)
4 = Asian	-.2123	-.2311	-.2447	-.1991
	(.230)	(.160)	(.124)	(.207)
5 = International	.0066	.4882	***.7983**	***.7504**
	(.964)	(.219)	(.038)	(.048)
6 = Unknown	-.0160	.0954	.1690	.1128
	(.934)	(.594)	(.358)	(.533)
Pre-Enrollment Data				
QGRE		****-.0077**	***-.0059**	***-.0053**
		(.000)	(.003)	(.007)
UG GPA		****-.4110**	***-.3353**	***-.3599**
		(.003)	(.010)	(.006)
MPAFF		-.0106	-.2986	-.1708
		(.884)	(.437)	(.653)
Teacher Dummy Variables				
LENTZ AM			***-.7929**	-.6253
			(.028)	(.085)
LUBY PFM			-.0614	-.1107
			(.511)	(.237)
MEYER IEM			****-.4910**	****-.4081**
			(.000)	(.003)
OLMS MICRO			-.0523	-.0208
			(.594)	(.830)
SPEL AMICRO			***-.2689**	***-.2617**
			(.010)	(.010)
WILSON IEM			***-.4919**	***-.4102**
			(.001)	(.004)

Table 16. Results from Linear Probability Regression Models with PROBATION (continued)

WILSON APE			-.2226	-.1087
			(.588)	(.788)
WONG IEM			***-.3596**	-.2733
			(.015)	(.074)
WONG AMICRO			***-.2920**	-.2211
			(.028)	(.106)
LBJ Math Readiness				
TIME IN ALEKS				-.0635
				(.126)
MATH REVIEW				-.0711
				(.371)
QFPP				.1091
				(.290)
Constant	.2895	2.353	2.555	2.369
R^2	.0208	.2184	.3994	.4416
*Significant at * $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$*				

When regressing on the dependent PROBATION variable, the overall fit of each model, represented by R^2, improved each time I added a new subclass from the dataset. Quantitative GRE scores and undergraduate GPA were the two most statistically significant explanatory variables; in both cases, the higher your score or GPA the less likely you were to be on probation. The teacher dummy variables controlled for students taking different quantitative courses and potential grading disparities and although a small number were statistically significant, there does not appear to be any systematic explanatory power for these variables. The LBJ math readiness variables – including time spent in ALEKS, attending the orientation math review sessions, and enrollment in the QFPP summer course – were not statistically significant predictors of quantitative probation when controlling for other variables.

Table 17 shows the resulting beta coefficients and fit statistics from four statistical models assessing the impact of the explanatory variables on a student's quantitative GPA during their first semester at the LBJ School.

Table 17. Results from OLS Regression Models with QGPA

REGRESSION OUTPUT ***QGPA Dependent Variable***				
	Betas			
Model	**(1)**	**(2)**	**(3)**	**(4)**
N	136	128	128	128
Demographic				
FEMALE	-.0569	-.0084	-.0902	-.1265
	(.608)	(.932)	(.356)	(.205)
AGE	-.0008	.0061	.0015	-.0017
	(.953)	(.622)	(.899)	(.888)
ETHNICITY				
1 = White only				
2 = Hispanic	-.1260	.1031	-.0226	.0376
	(.379)	(.401)	(.851)	(.760)
3 = Black	.2844	.6184	.5190	.5134
	(.512)	(.090)	(.139)	(.143)
4 = Asian	.3295	.3284	.2840	.2308
	(.197)	(.124)	(.180)	(.279)
5 = International	.2402	-.0590	-.4163	-.3766
	(.257)	(.908)	(.414)	(.460)
6 = Unknown	.3886	.1871	.1476	.2108
	(.163)	(.421)	(.547)	(.389)
Pre-Enrollment Data				
QGRE		*****.0179**	*****.0156**	*****.0147**
		(.000)	(.000)	(.000)
UG GPA		****.6070**	****.5202**	****.5474**
		(.001)	(.003)	(.002)
MPAFF		-.0836	-.0906	-.2384
		(.376)	(.860)	(.642)
Teacher Dummy Variables				
LENTZ AM			.6442	.4414
			(.178)	(.366)
LUBY PFM			.2038	***.2542**
			(.104)	(.046)
MEYER IEM			****.5729**	***.4867**
			(.001)	(.009)
OLMS MICRO			.1193	.0799
			(.363)	(.542)
SPEL AMICRO			***.3841**	***.3755**
			(.006)	(.007)
WILSON IEM			****.6460**	****.5575**
			(.001)	(.004)

Table 17. Results from OLS Regression Models with QGPA (continued)

WILSON APE			.2824	.1555
			(.607)	(.776)
WONG IEM			***.4812**	.3919
			(.015)	(.059)
WONG AMICRO			.2835	.1961
			(.109)	(.286)
LBJ Math Readiness				
TIME IN ALEKS				.0753
				(.179)
MATH REVIEW				.0448
				(.676)
QFPP				-.1473
				(.925)
Constant	3.380	-.0464	-.1431	.0875
R^2	.0496	.3775	.4924	.5171

Numbers in parentheses are p values.
*Significant at * $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$*

As with our PROBATION variable models, when regressing on the dependent QGPA variable, the overall fit of each model improved each time I added a new subclass from the dataset. Quantitative GRE scores and undergraduate GPA were again the two most statistically significant predictors, with positive associations with students' quantitative GPA at the LBJ School. The LBJ math readiness variables – including time spent in ALEKS, attending the orientation math review sessions, and enrollment in the QFPP summer course – were not statistically significant predictors of quantitative GPA.

Chapter 5: Discussion and Recommendations

FINDINGS

This study finds mixed evidence as to whether or not the LBJ School's 2017 math readiness program effected student outcomes in the short term. Based on the available data, the study was not designed to detect causality, but merely associations. The univariate and descriptive analysis showed strong empirical evidence of associations between the Phase 1 and Phase 2 components of the math readiness program and student quantitative performance. However, the associations between these explanatory and the dependent variables goes away in the final regression models. The study may be under-powered to detect significant associations between quantitative performance and certain components of the math readiness program, such as validation exam scores and the delta variables for students' self-assessed improvements over the summer.

Based on regression analysis, the strongest predictors of success in the quantitative core courses were undergraduate GPA and quantitative GRE scores. Qualitatively, student participation and feedback strongly support the school continuing to provide math resources for incoming students and offer some ideas for program modifications moving forward.

DISCUSSION AND RECOMMENDATIONS

The LBJ School's Math Readiness Program

This study yielded mixed findings that the LBJ School's new math readiness program was associated with student success outcomes in 2017. While causation, and thus the direct impact of the program, cannot be determined, there are many important takeaways to be found from both the qualitative and quantitative results.

One of the key reasons for performing any program evaluation is to assess the effectiveness of the program in the past in hopes of informing and improving the direction of the program in the future. Thus, when discussing the findings from this evaluation, it is important to keep in mind changes to the school's math readiness requirements that are already set in place for the near future. As mentioned earlier in this report, starting in 2018 two validation exams will be required for all incoming students as the only means of fulfilling the math prerequisites (which will be statistics and algebra for all students, regardless of degree program). This change is likely to make the math readiness program even more important to a greater number of students as the number of students taking the validation exams will more than double from 2017 to 2018.

In the following sections I discuss the key takeaways from this program evaluation, one phase at a time, and propose recommendations for future improvements.

Phase 1: Summer Self-Study

The summer self-study phase comprises the backbone of the math readiness program, when students begin to review and prepare for the quantitative coursework they will be taking a few months down the road. While the LBJ School traditionally offered students an in-person "Camp LBJ" learning experience, in 2017 the school focused on providing solely online resources over the summer months prior to on-campus orientation. Based on the qualitative and quantitative results detailed above, this report finds that the LBJ School should continue to use the online resources provided in 2017 and perhaps augment them with additional materials in 2018 when all students will be required to pass the validation exams before enrollment.

In the LBJ School's first year of using the ALEKS online learning platform, they saw a 50 percent overall participation rate and students who used the tool provided positive

feedback on the whole. One of the most telling data points is the fact that 100 percent of students who both used ALEKS and responded to the post-orientation survey would recommend ALEKS to future students. While univariate analysis showed that using ALEKS over the summer appeared to be associated with a lower likelihood of being on quantitative probation, there was no statistically significant association when controlling for other factors. Based on the students' self-assessed improvements in math over the summer (see Appendix E), students who used ALEKS were more likely to have achieved a greater increase in math knowledge by the end of the summer in algebra, statistics, and probability. So even if we can't show that using ALEKS directly impacted students' grades, it appears that using the program may help boost student confidence and their perceptions of their own math abilities.

Despite a lack of statistically significant evidence that the ALEKS tool directly impacted student outcomes in the short-term, this study finds no reason why the LBJ School should not continue to offer the accessible learning platform to students over the summer months leading up to matriculation. Furthermore, if all students are required to pass the validation exams in 2018, the school should expect to see a higher participation level for Phase 1 of the program, as more students will probably feel the need to prepare than in years past when students could fulfill the math prerequisites with formal coursework.

In addition to being a useful way to review math concepts, ALEKS also provides incoming students the benefit of taking a math assessment and having a true gauge of what they need to review and how much time they need to dedicate to studying math over the summer to be prepared for the semester. This assessment is a valuable practice that should be part of any effective math readiness program – how can students know how far they need to go over the summer if they do not know their own starting point? ALEKS is an

effective and efficient way of providing students with a helpful assessment while also capturing the data and results for administrative purposes.

Based on qualitative feedback, some students desired more instruction or explanations for concepts when they were using the ALEKS platform. One solution could be to provide supplemental learning materials for students who find themselves struggling with certain topics within the ALEKS learning modules. For example, the LBJ School could identify and share a list of existing videos from Khan academy or another online learning platform for students who want greater explanations in addition to the practice problems in ALEKS. Other than the time it would take to identify and list the existing materials to be shared with the students, this solution would not require many additional resources for the math program as it leverages existing content.

The second component of Phase 1, the Budnick textbook, received surprisingly good feedback qualitatively considering that it was just a textbook posted online without any supporting materials or engaging instruction. As with the ALEKS platform, univariate associations indicated students who used the Budnick text for self-study were less likely to be on quantitative probation. But similarly, Budnick was not a statistically significant predictor when I ran regression models that included the variable.[25]

In 2018 and beyond, calculus will no longer be a math prerequisite for LBJ School students in either degree program, so the Budnick textbook will be a markedly less important element of the summer math program moving forward. The textbook covers algebra and statistics in addition to calculus, but the student feedback seemed to indicate an overall preference for the more interactive ALEKS platform, which also covers these two subject areas. However, because the cost of providing access to the textbook is

[25] The USE BUDNICK variable was not included in the regression models detailed in this report because it reduced N to less than 60 students. However, I ran separate regressions with this smaller sample size and found no statistical significance for the explanatory variables.

extremely low and there were some students who appreciated having the supplemental learning materials in a different format, I would recommend the Budnick resource be offered as optional review for students with stronger math backgrounds or a more traditional learning style.

Phase 2: Orientation Review Sessions and Exams

Phase 2 took place during the LBJ School's two-week orientation. The review sessions were optional for all students, while the validation exams were required only for students who had not otherwise fulfilled their math prerequisites.

Qualitatively, students reported their satisfaction with the instructor for the math review sessions and appreciated the opportunity to participate in math review that was focused solely on what they needed to know for the validation exams or quantitative core courses. However, the student feedback also indicated that the orientation review sessions provided room for improvement (see Tables 8 and 9 for the full results).

One idea for improving the orientation review sessions – put forth in survey feedback by several LBJ School students and also currently in practice at other public policy schools – is to offer two separate levels of math review during orientation. By separating the students into two unique groups for math review, instructors can tailor the discussion and lessons to either a beginner level or more experienced level. While this would require additional resources and scheduling complexity on behalf of program staff, there could be educational dividends that would make the time in the review sessions more effective for everyone involved. One disadvantage to this two-cohort approach to the math review sessions is that it is a short-term fix: once the students begin their quantitative courses just two weeks later they will all be mixed together again and faculty members will need to teach across the varying math readiness levels. The LBJ School would also have

to determine how best to separate students into the two cohorts. The school could allow students to self-select into beginner or experienced math cohorts, or staff could proactively place students into groups based on admissions data, such as GRE scores.

In 2017, the two rounds of validation exams took place at the beginning and end of orientation. Quantitatively, the first round of validation exams appears to be strongly correlated with quantitative GPA outcomes (as shown in Table 15), but when controlling for other factors in a regression model those correlations go away.[26] Therefore, we cannot conclude that successfully passing the validation exams predicts student success in quantitative courses.

However, in subsequent years the validation exams will be used as an indicator for all students to show that they are prepared for quantitative coursework. The logic behind this transition is that allowing students to fulfill the math prerequisite with existing coursework does not necessarily mean those students are quantitatively prepared for the LBJ School – there is no way of ensuring the content and timing of these disparate courses from other schools is adequate to prepare students for the MPAff and MGPS degree programs. This mandatory validation exam approach can be found at other public policy schools known for their quantitative rigor, including Heinz College and Harris.

Because more students will be taking the validation exams in future years at the LBJ School, there will most likely be even more students participating in the math readiness program than ever before as they study and review to pass the exams. This will place an even greater emphasis on the first two phases of the program as more students are participating in summer self-study and attending the orientation review sessions.

[26] I performed regression analysis with the VEXAM variables, which greatly reduced N from 128 to 45. In this model the VEXAM variables were not statistically significant predictors of either the PROBATION or QGPA dependent variables.

Phase 3: In-Semester Support

To analyze the efficacy of the third phase of the LBJ School's math readiness program, I relied on qualitative feedback from the Math TA and the attendance records for the two aspects of the in-semester support – the drop-in tutoring sessions and the weekly review sessions. Both parts of the in-semester support had consistently low attendance in 2017 (as shown in Table 10). According to the Math TA many of the attendees were the same each week. Thus, even if this phase of the program was highly effective, it only impacted a small number of students.

Low attendance could be attributed to many different factors, such as scheduling, marketing, student capacity, or the timing of concepts covered. Drop-in tutoring sessions were scheduled five days a week at varying times and review sessions were offered every Friday afternoon. While Fridays are convenient for scheduling at the LBJ School because very few courses are offered that day, many students do not come to campus on Friday – they use the day for work and other obligations. The marketing for the program indicated that students could only seek help from the Math TA on conceptual math questions, not questions about problems or assignments from a class. While understandable, this language could also have confused students who also have access to teaching assistants (TAs) in each of their core courses. Perhaps students sought help from their course TAs instead of the Math TA even for conceptual math questions. For many graduate students, the first semester of the program is a very busy and potentially overwhelming time. Because of this, even the students who knew they needed help on math may not have felt that they had the capacity to add another office hour or review session to their schedule – especially if they feel it will not directly impact their grades.

In his reflection at the end of the semester, the Math TA had an insightful thought about the timing of the concepts covered in the math review sessions (the full schedule of

topics is listed in Table 10). The faculty members teaching the quantitative core courses developed the schedule so students could attend the review session to learn about a topic before the topic was covered in class. While this sounds logical in theory, in practice, it is unrealistic to expect students to know what topics they need extra help on before they encounter them in the classroom. Thus, the timing of the topics for the review session were essentially backwards – instead of scheduling a review session on linear regression before faculty members begin teaching linear regression in IEM, the review session on linear regression should come in the week(s) after the concept is covered in class. This way, students have time to recognize that they are struggling with the concept and seek help after the fact.

If the LBJ School needed to or wanted to cut some element of the math readiness program as it currently stands, this study would support eliminating Phase 3, the in-semester support. Alternatively, Phase 3 provides the most room for improvement within the program and could be a key area where the LBJ School continues to experiment, trying different methods to see what works best. The Ford School also implemented math office hours during the fall semester in 2017 and found their Sunday afternoon review sessions to be well attended, as many students are at school on Sundays completing homework and preparing for the week ahead. Another innovative approach being tested by the Ford School is the idea of targeted tutoring for students who are falling behind in the quantitative courses. Faculty members identify students in the bottom of the class after midterm exams and the school provides tutoring specifically for those students to help them during the rest of the semester. Given the low attendance at the LBJ School's math office hours and review sessions, using the in-semester resources in a more targeted manner could have a greater impact, especially for the students who are at the greatest risk of failing a class or getting placed on academic probation.

Overall, providing in-semester math support to help students be successful in the quantitative core curriculum is relatively unchartered territory – both at the LBJ School and at other public policy schools. Thus, the LBJ School should feel empowered to try different approaches over the coming years and see what works best for students in the program. Moving forward, I would recommend collecting student feedback – both from those who utilized the Math TA during the semester and those who did not – to discover what is working, how students feel about the resource, and why they did or did not access the resource for help.

Other Key Findings

As evidenced by the regression results in Tables 16 and 17, the only real statistically significant predictors of academic success in the quantitative core courses for the 2017 incoming class were factors determined before the students were admitted to the LBJ School: undergraduate GPA and quantitative GRE scores. While I would not advocate for changing the LBJ School's current admissions policy based on these findings, I do think these findings could inform discussion among the school's faculty and administrators as they determine admissions policies in the future and consider dedicating resources to math readiness for incoming students.[27] For example, if the school admits a greater number of students with low undergraduate GPAs or quantitative GRE scores in a future year, they may also want to consider dedicating additional resources to experimenting with math readiness.

Another aspect of math readiness at the LBJ School that falls outside of the three Phases of the formal program is the summer QFPP course for incoming students. Univariate analysis indicated that students who took QFPP were much more likely to be

[27] The LBJ School currently has no hard or soft floor for quantitative GRE scores when considering applicants for admissions.

on quantitative probation. However, when controlling for other factors this association was no longer statistically significant. Because QFPP will still be offered in 2018, but will no longer fulfill students' math prerequisites, the LBJ School should take a critical look at this component of math readiness again next year. Perhaps the QFPP curriculum could be used to inform online materials and other resources that are offered to all students over the summer as they prepare for the validation exams. It would be helpful if the post-orientation survey in future years includes a few questions for students who took this course to gather their qualitative feedback for comparison with those who opted for the self-study route.

LIMITATIONS

There are a number of limitations to the research and findings in this evaluation. This section focuses on the limitations that have the greatest potential impact on the quality of the findings and program evaluation, which include: the lack of probability sampling and a control group, the small sample size, the incomplete data set, the timeframe for analysis, and the lack of prior research studies on the topic of math readiness for graduate policy programs.

Because this is a one-cohort observational study, the quantitative analysis and findings are limited to this specific LBJ student cohort. It is not possible to generalize the applications of findings from this study beyond the 2017 student cohort nor beyond the LBJ School to a broader scale. With no control group or comparison cohort, the analysis is limited to associations. This study does not lend itself to making any casual determinations about the impact of the math readiness program on student outcomes beyond associations.

Furthermore, the sample size for this study (N=153 or fewer, depending on the model) was much smaller than ideal for a robust study, which further limits the significance of the findings. An incomplete data set exacerbated this small sample size, as some

explanatory variables had such small data populations that they had to be excluded from the regression models. This limited the model building process and left potentially relevant explanatory information out of the model.

The timing of this report, written just a few months after the LBJ School's incoming class of 2017 concluded their courses for their first semester, limits the analysis to short-term outcomes only. Ideally, a study would involve additional student outcome data to also assess the impact of the math readiness program on student success over a longer timeframe, as many first-year students take additional core quantitative courses in their second semester and beyond.

Because this study was conducted without a solid foundation of existing research on math readiness for public policy schools much of the analysis and discussion were experimental in nature. This is both a limitation to these findings and an area of opportunity for the LBJ School, which could continue to collect data on the math readiness program to inform a more longitudinal study of the impact on student outcome over the long term.

Overall, these combined limitations have significant implications for this study. At best, the findings from this program evaluation can be considered associations and should not be applied to student groups or programs outside the scope of this study until further research and analysis is performed.

THEMES FROM RESEARCH

After talking with faculty and staff at nine public policy schools across the U.S., it is clear math readiness is a topic of discussion for most graduate-level programs. While the level and rigor of quantitative prerequisites and curriculums vary across policy schools, most are offering some type(s) of math resource(s) over the summer to help students prepare for success in their core quantitative courses. The brief environmental scan I

performed to provide context for the LBJ School's program evaluation revealed some interesting themes and trade-offs for further discussion.

"Camping" is Still a Trend

Many schools refer to their math readiness programs as "camps," although they can vary in timing, duration, content, and obligation. Six of the nine policy schools included in my environmental scan currently hold some form of math camp each summer before the semester begins. As discussed earlier, the LBJ School also held an annual summer camp with an extensive math component until the new three-phase program was implemented in 2017. Most math camps are scheduled immediately before the start of the semester or concurrently with orientation, but they vary in duration, from as short as three days to as long as four weeks. With the exception of one school, which provides an invite-only math camp for targeted students, math camps are largely optional but often well attended.

This camping trend may have been influenced by Wechsler and Baker's article in 2004, published in the Journal of Public Affairs Education (JPAE), which highlighted "camping" as a promising practice that provides "substantial benefits" to policy schools.[28] At the time of the article, the authors highlighted summer camps at the LBJ School and the Truman School to share innovative approaches and best practices, but found that camping was not yet widely adopted. In addition to this key article, it is likely that these two highlighted policy schools shared their math readiness ideas and successes through formal networks – such as the Network of Schools of Public Policy, Affairs, and Administration (NASPAA) – and informal networks, such as existing cross-institutional faculty relationships.

[28] Wechsler and Baker, "Going Camping: A New Strategy for Preparing Academically Diverse Students."

Using the Summer Months

As evidenced by the camping trend, most math readiness programs occur during the months or weeks immediately preceding matriculation. This is consistent with the idea that students need intensive math review or preparation before starting the quantitative policy curriculum. The idea behind summer math preparation is to try to level-set the math skills and knowledge across the incoming student cohort.

While less common, a few schools, including the LBJ School, are also experimenting with providing supplemental math resources during the semester to support students needing remedial help as they work through their core quantitative courses. Similar to the LBJ School, the Wagner and Ford Schools are piloting in-semester math tutors who provide drop-in sessions to support students on a weekly basis. The Ford School also pays for group or individual tutors for students in the bottom quartile of the quantitative core courses, as identified by faculty members teaching those courses.

The following sections highlight some of the tradeoffs policy schools are faced with when crafting math readiness programs and identify a few advantages and disadvantages for each option.

Online or In-Person

Math readiness programs for graduate policy students are currently a mix of online and in-person. The types of online math resources used can range from static (readings, lecture notes), dynamic (videos, problem sets), to interactive/adaptive (ALEKs or other). A few schools, including the LBJ School, use a combination of both online self-study and in-person instruction to provide multiple opportunities for students who need math review.

There are several advantages to providing online learning tools for students: it allows for self-paced studying, it is highly accessible for students in any location over the summer, and it enables students to adjust the time they spend studying and reviewing to

their unique needs. Online learning tools eliminate a lot of barriers for incoming students who need to review over the summer, as students can review pertinent math concepts from any location, at any time, and for any length of time. Of course, there are also disadvantages to online learning tools, including: students are learning in isolation with no opportunities to ask questions, there are no opportunities for relationship building with other students or faculty, and there may be limited feedback provided for students as they learn, depending on the type of materials provided online. While static math materials provide no feedback or opportunities for questions, adaptive learning tools like ALEKS provide more information to let students know how they are progressing and what concepts they still need to work on.

There are advantages to in-person learning for math readiness prior to matriculation for similar reasons as to why all the policy schools in this study provide campus-based instruction during the regular school year. Advantages include the opportunity for social learning and building relationships with other students and faculty, reintroduction to the classroom learning environment, and the opportunity for instructors to adjust content to the needs of students and provide individual feedback and answers to student questions in real time.

There are also some disadvantages to in-person learning, which were highlighted in the student feedback on the LBJ School's orientation math review sessions (discussed above). With in-person instruction, it can be challenging to teach effectively across the students' differing math readiness baselines. In other words, while covering any given set of concepts, some students may fall behind while other students may be bored. In-person instruction can also be more resource-intensive than online learning, given the cost of faculty or doctoral student instruction. Of course, when students are required to come to campus to attend in-person learning sessions, it reduces the accessibility to those who have

the scheduling and financial flexibility to be on campus before the beginning of the semester.

Targeted or Blanket Offerings

While some schools target only specific students for math preparation before matriculation, others take a more blanket approach of offering math resources for all students. For example, Heinz College and the Harris School both offer invite-only math readiness courses for students who their admissions team identifies as needing supplementary preparation before matriculating. All other math readiness programs in this study were blanket offerings open to or required of all incoming students.

Targeted programs are meant to get students at the bottom of the math readiness spectrum caught up with their peers before enrolling in quantitative core classes. This approach could utilize less resources than a blanket approach if it is serving a small proportion of the student body. It can also allow for more individualized instruction and create an environment where students feel comfortable learning with other students of a similar math background.

However, targeted programs could prove challenging if the selection and identification process to place students into the math readiness program misses some students who truly needed math instruction and review. There is also the question of how to identify students who need help – should it be based on GRE scores, the results of a math assessment, or another factor? Depending on the culture surrounding the program, a targeted math readiness course could create or perpetuate confidence issues when students know they have been identified as the most in need of math help. In comparison to a blanket math readiness program, a targeted program is inherently less accessible because not all students have access to the resources being provided by the school.

Offering all students access to the same math readiness resources is the most common approach taken by the policy schools in this study, allowing all students the chance to prepare for their quantitative curriculum with the same tools and materials as their peers. One advantage to this approach is that it can empower students with the ability to determine how much time they need or want to dedicate to math preparation before the semester begins based on their individual needs. A more holistic offering can also help prevent some students from falling through the cracks, which might happen if the math readiness program is by invitation only.

However, the blanket approach comes with its own disadvantages, including: possibly requiring more resources (depending on size and format of program), an increased challenge of providing the individualized attention needed by students at the bottom of the math preparedness spectrum, relying on students to be proactive and capable of evaluating their own needs, and the demand for developing materials to effectively cover the wider range of students' needs and different levels of math readiness.

As evidenced by this environmental scan of policy schools, there are many different choices a school can make when developing or implementing a math readiness program: when to provide math resources and for how long; whether to offer resources online, in-person, or both; and who to share the resources with – either a targeted group of students who need the most help, or all incoming students across the spectrum of math preparedness.

There have not been any formal studies conducted to determine which of these options, or combination of options, is the most effective for creating a solid math baseline for incoming students and helping them achieve success in their quantitative core curriculum. At this time, each school should continue to regularly assess their own existing program and collect and analyze student data to determine effectiveness (if possible). Future research is necessary to answer questions of program effectiveness that would apply

across peer public policy schools. Based on the demonstrated need for math readiness at almost all public policy schools I spoke with to inform this discussion, I encourage increased dialogue and sharing of best practices across institutions to improve student success and program efficiency on a broader scale.

CONCLUSION

This report set out to determine whether or not the evidence showed that the LBJ School's math readiness program drove student outcomes in 2017. In the end, the evidence was mixed in showing that the program's effectiveness in leveling the diverse student body's math baselines in preparation for the quantitative core courses. However, an environmental scan of eight additional public policy schools indicates that the LBJ School continues to be a leading experimenter and innovator among its peers when it comes to math readiness. The LBJ School should continue to monitor and assess the efficacy of the three phases implemented in 2017 as they move to a more standardized approach to math prerequisites across all incoming students in 2018.

Overall, the exercise of performing the program evaluation showed how complex it can be to support a diverse group of graduate-level students as they prepare for rigorous quantitative work. After discussing this challenge with leading faculty and staff at policy schools across the country, it seems that students will be best served by schools that are willing to try new things, consistently reevaluate while constantly working towards program improvements, and participate in open dialogue with students, faculty, and even other policy schools to share new ideas and best practices.

Appendices

APPENDIX A: FULL ENVIRONMENTAL SCAN OF MATH READINESS PROGRAMS

The following information was informed by interviews with a faculty or staff member at each institution and the program website. See Table 1 for a list of interviewees.

Carnegie Mellon University
Heinz College

- *Relevant Degree Programs:* Master of Science in Public Policy and Management (MSPPM)
- *Admissions:* Students admitted to the MSPPM program are required to have undergraduate coursework or comparable work experience in advanced algebra, pre-calculus, probability, and statistics prior to their first semester at Heinz College. Students can meet this requirement by completing a college-level course with a grade of B or higher covering these topics. Applicants are not required to complete their math prerequisites before applying to Heinz College, but are required to complete them before beginning classes.

  Heinz College has analyzed student data and found that GRE scores are not a huge predictor of success – especially in cases where students have been working for some time after their undergraduate studies. Therefore, the admissions team does not "anchor on a number for GRE," but looks at GRE in combination with undergraduate coursework. If a student does poorly on the GRE and does not have a quantitative background, the staff will flag them to attend the summer math program, QSSP (detailed below). Strong candidates with weak math backgrounds can be given admission pending completion and passing of QSSP.

  Overall, most admitted students at Heinz College have strong quantitative skills.

- *Math Assessment:* All incoming students must pass a math assessment exam once they arrive on campus before they officially start the program. They are given multiple attempts, but if they do not pass they will not join the program.
- *Quantitative Core Courses:* (for MSSPM students) "Applied Economic Analysis," "Statistical Methods," "Intro to Database Management," "Management Science," "Financial Analysis"
- *Formal Math Programs:*
  Heinz College "Quantitative Skills Summer Program" (QSSP)

Duration	- Four weeks
Timing	- During the summer
Format	- In-person

	- Comprised of two modules: (1) Math Refresher, (2) Statistics - Students must pass both modules (earning a B or better) - Concepts and skills covered include: applied pre-calculus and problem application, graphing, basic statistics and probability, spreadsheets, and statistical software skills
Participation	- Most attendees are required by the program to participate - Not advertised to all incoming students - No cost to participants - About 20% of the incoming class participates (21 out of 97 total students in 2017)

Heinz College "Excel Bootcamp"

Duration	- One weekend
Timing	- *Unknown*
Format	- In-person - Meant to prepare students for the Management Science course
Participation	- Optional

- *Informal Math Programs:* N/A
- *In-Semester Resources:* N/A
- *Other Comments:* Heinz College also has a part-time Master of Public Management (MPM) program for local students with at least 3-4 years of work experience. This program is an accelerated version of the MSPPM program, with a very similar curriculum, but lighter quantitative coursework. MPM applicants are not required to take the GRE, so Heinz College developed a math review and assessment program to help the school ensure incoming part-time students were meeting a threshold of quantitative aptitude.

  The part-time MPM incoming student math review program used to be in-person, but in 2017-2018 was moved to be all online (with the exception of the on-campus written exam that all students must pass before the semester begins). There is no TA nor instruction involved in the program. This math program is viewed as a precursor for entry into the MPM program. Students have access to an online self-study module that provides review materials for economics and statistics. Heinz College custom-built the online program (in the Canvas platform) and the format includes lessons (e.g. videos, white boards, and slide decks) paired with practice problems. In the future, Heinz College administrators want to have students do a self-assessment survey before and after the self-study program and exam in order to conduct a longitudinal analysis with GRE scores.

Interestingly, the school found that many MSPPM students from the full-time program have opted to use the MPM online resource over the summer as a refresher course before they enroll. Now, the administration anticipates that as soon as next year they will move the QSSP for MSPPM students to be all online as well. During the transition, they are considering including a TA or instructor for students to access in addition to the online materials.

Heinz College would also like to move away from the Canvas platform and use a more adaptive online learning platform – most likely from CMU's Online Learning Initiative – which they believe would be better for the students, give the school more data to analyze, and improve the program overall.[29] They worked closely with the CMU Teaching Center and the quantitative core faculty at Heinz College to develop the existing online math content.

Indiana University – Bloomington
School of Public and Environmental Affairs (SPEA)

- *Relevant Degree Programs:* Master of Public Affairs (MPAff)
- *Admissions:* There are no prerequisites and the school conducts a "very holistic" admissions review process.
- *Math Assessment:* Not answered.
- *Quantitative Core Courses:* "Statistical Analysis for Effective Decision Making," "Public Management Economics," "Public Finance and Budgeting"
- *Formal Math Programs:* SPEA "Math Camp"

Duration	- One week
Timing	- Directly precedes orientation, which occurs right before classes start
Format	- In-person - Split into regular and advanced sections, into which students self-select - Regular section (which most MPAs attend) covers economics and statistics, while the advanced section (which is more for MSES students) additionally covers calculus - Topics include both mechanical and conceptual math - Taught by a faculty member
Participation	- Optional - About half of all incoming graduate students participate each year (total graduate enrollment is 580)

[29] CMU's Online Learning Initiative develops custom online courses. For more information, see: http://oli.cmu.edu/

- *Informal Math Programs:* Pre-Math Camp reading guides, which include suggested readings from faculty members, are distributed to all incoming students regardless of math camp participation.
- *In-Semester Resources:* Not answered.
- *Other Comments:* Attending math camp may be required as a condition of admission for a select number of students.

New York University
Wagner Graduate School of Public Service (Wagner)

- *Relevant Degree Programs:* Master of Public Administration (MPA)
- *Admissions:* There is no explicit GPA threshold nor specific course requirements for MPA admissions. Furthermore, Wagner does not require applicants to take the GRE. They have a mix of students with significant quantitative backgrounds and some with little-to-none.
- *Math Assessment:* Wagner does not offer any separate math assessment outside their online adaptive learning program, which is used to help students self-assess their math readiness needs and determine if they should attend review sessions before and/or during the semester.
- *Quantitative Core Courses:* "Statistical Methods for Public, Nonprofit, and Health Management," "Microeconomics for Public Management, Planning, and Policy Analysis," "Financial Management for Public, Nonprofit, and Health Organizations"
- *Formal Math Programs:* Two Parts

(1) "Online Adaptive Learning Program" (ALEKS® tool)

Duration	- Self-paced - Can be accessed over months, weeks, or days
Timing	- During the months leading up to students' first semester - Wagner has two incoming cohorts each year, in the fall and spring - Also available during the semester, as needed
Format	- Online - Using ALEKS adaptive assessment and learning system (from McGraw Hill)
Participation	- Optional - Considering whether or not to make it required

(2) Wagner "Math Review Workshops"

Duration	- Held weekly
Timing	- Before and during the semester
Format	- In-person

	- Taught by PhD candidates or adjunct faculty - Covers mechanical, conceptual, and contextual material (starting with mechanical review and moving to conceptual/contextual) - Concurrent math review sessions start during the fifth week of the semester, which allows students some time in their classes to figure out for which topics they need to seek help
Participation	- Optional

- *Informal Math Programs*: N/A
- *In-Semester Resources*: In addition to the concurrent math review sessions offered during the semester (detailed above), Wagner offers drop-in group tutoring sessions for their quantitative core courses. Tutors are peer students from the masters programs. Each quantitative course is comprised of a weekly lecture and separate discussion section, the latter taught by an "adjunct TA" who could be a masters student, alumni, or other. These weekly course discussions are separate from the drop-in tutoring sessions.
- *Other Comments:* As the Wagner administration looks at their math readiness scaffolding and how best to support students early on in the program, the online learning tool, ALEKS, is a big part of that conversation. As of Fall 2017 they have used the tool for four years, for two incoming cohorts each year (fall and spring). Student feedback indicates that students like ALEKS and find it helpful. More specifically, the school is taking a look at ALEKS to figure out how to create a stronger link between the concepts covered on ALEKS and the in-person math review sessions. They are also considering whether or not to make ALEKS required so all incoming students know where they stand and where they may need to seek help.

University of California Berkeley
Goldman School of Public Policy (GSPP)*

- *Relevant Degree Programs*: Master of Public Policy (MPP) and Master of Public Affairs (MPAff) for mid-career students
- *Admissions:* Applicants are strongly encouraged to have taken at least one of the following introductory courses: microeconomics, statistics, or calculus. If they have not taken these courses, the school gives stronger weight to GRE scores. GSPP administrators feel it is important to have evidence that applicants can handle the rigorous quantitative and analytical courses within the MPP Program. According to the school's website: "GSPP does not require prior quantitative training; however prior course work in introductory statistics or first-year calculus, and introductory economics, is strongly recommended."

- *Math Assessment:* Not Answered.
- *Quantitative Core Courses:* "Decision Analysis, Modeling, and Quantitative Methods," "The Economics of Public Policy Analysis"
- *Formal Math Programs:* GSPP "Math Camp"

Duration	- Two weeks
Timing	- Directly before the semester starts
Format	- In-person - Taught by a lecturer - Refresher course to help prepare students to enter the program
Participation	- Optional

- *Informal Math Program:* Not Answered.
- *In-Semester Resources:* Not Answered.

*Note: this information was provided via email and the opportunity for follow-up questions was not available.

University of Chicago
Harris Public Policy (Harris)

- *Relevant Degree Programs:* Master of Public Policy (MPP)
- *Admissions:* The school does not have any hard admissions rules for GRE or quantitative prerequisites. However, they use these two factors to identify students who might have problems in the math core courses and proactively invite them to attend pre-orientation math programs.

  From the Harris admissions website: "While no specific experience is required for our degree programs, students with a strong liberal arts background and sound quantitative and analytical skills will be best prepared to thrive....to help incoming full-time students who need a boost in any of these areas, we offer several academic support programs, including pre-orientation programs in English (for international students) and math."

- *Math Assessment:* In addition to the self-assessment exam given to students at the beginning of the summer, Harris has a mandatory math exam that is held during orientation week.[30] The exam is a degree requirement, covering algebra and calculus, meant to ensure students are quantitatively prepared for the statistics and economics core coursework.

[30] Sample exams from Harris (2017) are available at:
http://harris.uchicago.edu/files/algebra_example_exam_2017.pdf
http://harris.uchicago.edu/files/calculus_example_exam_2017.pdf

From the Harris website: "If you do not pass one or both portions of the math exams, you will need to enroll in a non-credit math course during autumn quarter…There is no tuition and there are no fees associated with these courses. These courses are graded on a pass/fail basis."

These non-credit math courses have approximately 30-40 students out of 300 total incoming students. They run concurrently with core quantitative courses and the curriculum is not coordinated strongly between the two. The algebra class is close to "tutorial level" and calculus unfolds with a standard curriculum. There are also other resources available to students who need extra help.

- *Quantitative Core Courses:* "Statistics for Data Analysis I and II," "Principles of Microeconomics and Public Policy I and II"
- *Formal Math Programs:* Harris "Math Camp" (HMMP)

Duration	- Three weeks
Timing	- Directly before the semester starts
Format	- In-person[31] - Review course in algebra and calculus - Students can test out of the algebra portion of camp
Participation	- Optional - All enrolling students are encouraged to participate - Students take two self-assessment exams at the beginning of summer to determine their need to participate in the camp (and self-report their scores to the program) - Around 70% of incoming students attend camp each year (out of 300 total enrolling students) - Of those who attend, many are students who have been out of school for longer or who did not have much math in their undergraduate coursework

Harris "Jumpstart Program"[32]

Duration	- Two weeks
Timing	- *Unknown*
Format	- Custom program, specifically designed for enrolling students with a limited quantitative background prior to joining Harris (as identified by the admission's committee)

[31] See a sample schedule of Harris's HMMP: https://harris.uchicago.edu/files/hmpp_overview_2017_1.pdf

[32] For more details on Harris's Jumpstart Program, see: http://harris.uchicago.edu/admitted-students/orientation-programs/jumpstart

Participation	- Invitation only, based on admissions committee's recommendations - No cost to participate - This program is new and in the first year (2017) they had 40 out of 300 students participate

- *Informal Math Programs:* Harris provides study resources over the summer for students to self-study. Supplemental study materials include online lectures and practice materials for students to review material covered in the self-assessments and prepare them for the HMPP and the mandatory math exams. Study resources include links to Khan Academy videos.[33]
- *In-Semester Resources:* N/A
- *Other Comments:* Harris is investing a fair amount in these math resources because they believe many students have something special in their background that offsets their lack of quantitative experience.

  The school recognizes that math readiness is resource intensive and they are continually assessing the summer math readiness programs to see how they can be improved. Harris administrators feel that the whole purpose of these programs is to get people prepared for the core coursework. Harris staff continually look at which students did poorly in the core and try to understand why; did that particular student have math issues and did they avail themselves of the available resources?

  Harris's definition of success for their math readiness programs is getting people successfully through the core.

  The school is discussing add a "Coding Camp" next summer for incoming students that will include a basic introduction to how computing, programming, and statistics are used in the context of public policy. Currently, core courses include the use of both R and Stata (employers encouraged the school to teach R, which they added to the curriculum one year ago). The school also offers a programming course for students interested in learning python.

University of Georgia
School of Public and International Affairs (SPIA)

- *Relevant Degree Programs:* Master of Public Administration (MPA)
- *Quantitative Core Courses:* "Public Financial Administration," "Economic Foundations of Policy Analysis," "Research Methods"

[33] Harris's list of math resources: http://harris.uchicago.edu/files/harris_mathematics_pre-core_program_curriculum_resources.pdf

- *Other Comments:* The University of Georgia's MPA program does not have any quantitative admissions requirements nor do they have any math readiness programs. According to Dr. Edward Kellough, the MPA Program Director, "there is little math readiness" SPIA's MPA students need to master given the nature of the program, underscoring the difference in quantitative curriculum between Master of Public Administration programs (MPA) and Master of Public Policy (MPP) programs.

University of Texas at Austin
LBJ School of Public Affairs (LBJ School)

- *Relevant Degree Programs:* Master of Public Affairs (MPAff) and Master of Global Policy Studies (MGPS)
  Admissions: Students applying to the MPAff and MGPS programs "will be expected to have an understanding of descriptive statistics, probability and algebra before beginning coursework." Incoming students are required to either have completed formal coursework in statistics and calculus (whether undergraduate, at a community college, or at the LBJ School prior to matriculation) or pass validation exams during orientation.
- *Math Assessment:* The LBJ School provides two math validation exams during orientation – one for probability and statistics and one for algebra and calculus. Passing these exams is a requirement for any MPAff student who did not fulfill the math prerequisites with coursework. However, all students are encouraged to take the exams to self-assess their abilities going into their first semester of quantitative core courses. Starting in 2018 the math validation exams will be required for all incoming MPAff and MGPS students at the LBJ School.

  There is also an opportunity for students to take an informal math assessment, online, as part of the summer self-study phase of the LBJ School's program (detailed below). This assessment gives students an understanding of where they need to focus their math review over the summer.

- *Quantitative Core Courses:* For MPAff students – "Intro to Empirical Methods for Policy Analysis," "Advanced Empirical Methods for Policy Analysis," "Applied Microeconomics," "Advanced Policy Economics," "Public Financial Management;"; for MGPS students – "Analytical Methods for Global Policy Studies," "Microeconomics for Global Policy Studies"
- *Formal Math Programs:* Three Phases
  Phase (1) LBJ School "Summer Self-Study"

Duration	- Self-paced - Can be accessed over months, weeks, or days
Timing	- During the summer
Format	- Online

	- Using ALEKS® adaptive assessment and learning system (from McGraw Hill) to cover algebra, probability, and statistics - Using online copy of math textbook to cover calculus review materials[34]
Participation	- Optional, but strongly recommended

Phase (2) LBJ School "Orientation Review Sessions"

Duration	- Two weeks
Timing	- During orientation, immediately preceding the start of the fall semester
Format	- Taught by PhD candidate - Covered statistics and calculus materials to help students prepare for core courses and pass the math validation exams - Daily math review sessions throughout orientation, each covering a different topic
Participation	- Optional, but strongly recommended - Orientation is mandatory for all incoming masters students, but math review sessions are optional

Phase (3) LBJ School "Ongoing Fall Math Support"

Duration	- 13 weeks
Timing	- Duration of the Fall semester
Format	- Two components, both hosted by a masters-level TA: (1) open office hours, and (2) weekly review sessions - Office hours serve as resource for students struggling with math concepts (not meant for help on homework or graded assignments); held five days per week - Weekly review sessions are topical, and run parallel with the topics covered in quantitative core classes; held once a week on Friday
Participation	- Optional - In the first year of the program (2017), TA office hours and review sessions had relatively low attendance, with anywhere from zero to eight students using these resources per week (averaging four students per week across all weeks)

- *Informal Math Program:* N/A

[34] As of 2017, the LBJ School is using an online version of the following textbook for summer calculus review: Budnick, *Applied Mathematics for Business, Economics and the Social Sciences*.

- *In-Semester Resources:* See Phase (3), above.
- *Other Comments:* The LBJ School also offers a formal summer math review course for incoming students, titled "Quantitative Foundations for Public Policy," taught by an LBJ School faculty member in June and July. This course requires tuition payment and does not count towards the students' masters degree completion. Between 20-30 incoming students participate in this optional course each summer. The course covers a review of algebra, probability, statistics, and differential calculus that is tailored towards the concepts and skills needed for success in the LBJ School's core curriculum. This summer math course has been offered for over two decades but is not accessible to all incoming students for financial and scheduling reasons.

University of Michigan – Ann Arbor
Gerald R. Ford School of Public Policy (Ford School)

- *Relevant Degree Programs:* Master of Public Policy (MPP)
- *Admissions:* There are no quantitative prerequisites. The school looks at GRE scores and quantitative experience in the context of the holistic application.
- *Math Assessment:* N/A
- *Quantitative Core Courses:* "Calculus," "Statistics," "Microeconomics," "Quantitative Methods for Program Evaluation," "Applied Econometrics"
- *Formal Math Programs:* Ford School "Math Camp"

Duration	- Three to four days - Eight total hours of curriculum
Timing	- Concurrent with orientation
Format	- In-person - Refresher course with a heavy emphasis on algebra - Covers both mechanical and conceptual math, but heavier on mechanics (e.g. solving equations, dealing with exponents, factoring algebraic expressions, functional notation, simultaneous equations) - Materials covered are based on discussions with faculty who teach the quantitative core courses (including Calculus, Statistics, Microeconomics I and II), which helps determine what students need to be successful in their courses
Participation	- Required (as part of orientation)

- *Informal Math Programs:* Summer reading lists are provided to students who feel they need additional math preparation over the summer.
- *In-Semester Resources:* Resources provided during the semester (but outside of class) include course TA office hours, class discussion sessions, paid tutors for

students in the bottom quintile of certain quantitative classes, and math office hours.

Every quantitative course has one or two TAs who are graduate student assistants. The school allows professors to identify students in the bottom quintile of his or her class – after the first exam – and provides targeted resources for those select students by hiring and paying tutors for them.

In Fall 2017 the Ford School added math office hours to provide students help with remedial math concepts (not to help with homework). Math office hours were held by a masters student with a strong quantitative background who had previously been the TA for calculus or other quantitative courses. Math office hours were "super busy" and have yielded positive reviews from students. They were held on Sundays, because it was determined that many students are in the building that day, studying and preparing for the week ahead.

- *Other Comments:* The Ford School feels they put a lot of effort and resources into math readiness, which they believe contributes to the rareness of students failing the core quantitative courses. Over the last several years they have felt the need to put more effort into these programs. Although the Ford School's curriculum has not changed, they are noticing the math readiness of incoming students is not the same as it has been in the past. They increased their class size a bit recently and found they had to dedicate more time, resources, and attention to math preparedness as a result.

University of Washington
Evans School of Public Policy and Governance (Evans School)

- *Relevant Degree Programs:* Master of Public Administration (MPA)
- *Admissions:* There are no formal prerequisites, but applicants with prior coursework in introductory microeconomics or statistics may be more competitive for admissions. The majority of incoming students have taken statistics and/or microeconomics during their undergraduate studies. Sometimes the admissions team will recommend an incoming student to take a quantitative course at a local community college before enrolling. Historically, the students who have struggled in the program are the students with lower GRE quantitative scores and those who have not taken statistics or economics before enrolling.
- *Math Assessment:* The Evans School offers a set of math practice problems, which all students are encouraged to complete to help them assess whether math camp would be a good use of their time. The practice problems are provided early in the summer and test concepts for Economics I and Statistics II. The school provides the solution key to the students and indicates a threshold for whether or

not they should attend math camp. A majority of incoming students complete these math practice problems.

- *Quantitative Core Courses:* "Quantitative Analysis I and II," "Public Budgeting and Financial Management," "Microeconomic Policy Analysis"
- *Formal Math Programs:* Evans School "Math Camp"

Duration	- Two-and-a-half days
Timing	- Before the semester starts
Format	- In-person - Taught by a PhD candidate
Participation	- Optional - Students pay $50 - Capacity of 65 students (out of 190 incoming class) - Demand was greater than capacity in 2017 and the school has seen an increase in the number of students using math resources over the summer

- *Informal Math Programs:* The Evans School provides a list of online resources for students to access over the summer – including links to Khan Academy (for economics and statistics courses), government resources, and book chapters. These resources are optional, but the school communicates that they are "strongly recommended" and that students who prepare over the summer do better in the fall semester.
- *In-Semester Resources*: Student services staff help connect masters students with PhD students for independent tutoring during the semester. The school does not pay for the tutoring, they simply help connect students who need help.
- *Other Comments:* The Evans School used to offer an official summer prep course ("Introduction to Microeconomics") but enrollment was low. They felt the main barriers for students were cost and the inability to move to Seattle earlier in the summer. They discontinued this offering due to low enrollment.

  Part of the Evans School's strategic plan is to grow the student body. As each incoming class becomes larger, the number of incoming students with no background in economics or statistics has also grown. This has created new challenges in balancing faculty expectations of student preparedness with admissions standards as the student body grows.

APPENDIX B: ENVIRONMENTAL SCAN INTERVIEW QUESTIONS

1. What are your quantitative admissions requirements for masters candidates?
    a. E.g. quantitative prerequisites, GRE scores, or other?
    b. Do you have a hard or soft floor for GRE quantitative scores?
2. Does your school have a math readiness program for newly admitted students (whether formal, informal, or nonexistent)?
    a. What does the program entail?
        i. Is it formal or informal?
        ii. Is it optional or required?
        iii. Do you offer any type of math assessment or exams prior to the first semester? If so, are they mandatory?
        iv. What's the timeline (i.e. summer, fall, both)?
    b. What proportion of incoming students participate?
    c. How do you measure the success of the program (if at all)?
        i. Do you have any data or materials to share?
3. Is math readiness something the faculty and administrators at your school are discussing? Are there any upcoming changes planned or under development?
4. Are there any other math readiness programs your school has considered or tried in the past?
    a. If so, please elaborate.
5. Is there anything you would like to add regarding your school's approach to or consideration of math readiness for masters students?

APPENDIX C: INSTITUTIONAL WEBSITES CONSULTED FOR ENVIRONMENTAL SCAN

Carnegie Mellon University **Heinz College**	https://www.heinz.cmu.edu/
Indiana University – Bloomington **SPEA**	https://spea.indiana.edu/
New York University **Wagner**	https://wagner.nyu.edu/
University of California – Berkeley **Goldman**	https://gspp.berkeley.edu/
University of Chicago **Harris**	https://harris.uchicago.edu/
University of Georgia **SPIA**	http://spia.uga.edu/departments-centers/padp/
University of Texas at Austin **LBJ School**	https://lbj.utexas.edu/
University of Michigan – Ann Arbor **Ford School**	http://fordschool.umich.edu/
University of Washington **Evans School**	https://evans.uw.edu/

APPENDIX D: LBJ SCHOOL QUESTIONS FROM POST-ORIENTATION SURVEY

Quantitative Background Questions	• Undergraduate Major?
	• Undergraduate Minor?
	• When was the last time you took a formal course in **probability or statistics?**
	  o (e.g. summer '17, fall '12)
	• When was the last time you used **probability or statistics** in a meaningful way (other coursework, job, daily life?)
	• When was the last time you took a formal course in **algebra?**
	  o (e.g., summer '17; fall '12)
	• When was the last time you used **algebra** in a meaningful way (other coursework, job, daily life?)
	• When was the last time you took a formal course in **calculus?**
	  o (e.g., summer '17; fall '12)
	• When was the last time you used **calculus** in a meaningful way (other coursework, job, daily life?)

Self-Assessment Questions	• Please indicate **how much you knew at the start of the summer** about the following subjects on a scale from 1 to 5, roughly as follows: 1 = do not know it at all 2 = know it somewhat (or used to know it well and am very rusty) 3 = know it fairly well 4 = am pretty good at it 5 = could teach the subject ____ Probability ____ Descriptive statistics ____ Algebra ____ Differential calculus • Using the same scale as above (1 to 5), please indicate **how much you know now:** ____ Probability ____ Descriptive statistics ____ Algebra ____ Differential calculus

Math Readiness Program Questions	• If you used ALEKS (at all, even for a second), please tell us…
	  o What you liked
	  o What you did not like
	  o Would you recommend ALEKS to next year's cohort?
	• If you used the Budnick reading materials (at all, even for a second) posted on Canvas, please tell us…
	  o What you liked
	  o What you did not like
	  o Would you recommend the Budnick readings to next year's cohort?
	• If you attended any of the math review workshops taught by [LBJ School PhD candidate], please tell us…
	  o What you liked
	  o What you did not like
	  o Suggestions for next year?

APPENDIX E: STUDENT SELF-ASSESSMENT QUESTION SURVEY RESULTS

Algebra Self-Assessment

	End of Summer					
Beginning		**2**	**3**	**4**	**5**	**Total**
1		1				**1**
2		7	10	3		**20**
3			7	11		**18**
4		1		29	5	**35**
5					16	**16**
Total		**9**	**17**	**43**	**21**	**90**

Statistics Self-Assessment

	End of Summer					
Beginning	**1**	**2**	**3**	**4**	**5**	**Total**
1	1	6	4	1		**12**
2		8	19	9		**36**
3			10	9		**19**
4				18	4	**22**
5					1	**1**
Total	**1**	**14**	**33**	**37**	**5**	**90**

Probability Self-Assessment

	End of Summer					
Beginning	**1**	**2**	**3**	**4**	**5**	**Total**
1	1	2	3	1		**7**
2		13	13	12		**38**
3			13	11		**24**
4			1	17	2	**20**
5					1	**1**
Total	**1**	**15**	**30**	**41**	**3**	**90**

Calculus Self-Assessment

	End of Summer					
Beginning	**1**	**2**	**3**	**4**	**5**	**Total**
1	10	13	9	3		**35**
2		10	14	10		**34**
3			4	6		**10**
4				10		**10**
5					1	**1**
Total	**10**	**23**	**27**	**29**	**1**	**90**

Algebra	Used ALEKS		Did NOT use ALEKS	
Distribution of Δ's	Students	Percent	Students	Percent
-4	0	0	0	0
-3	0	0	0	0
-2	0	0	1	3%
-1	0	0	0	0
0	30	57%	29	78%
1	20	38%	7	19%
2	3	6%	0	0
3	0	0	0	0
4	0	0	0	0
Total	**53**	100%	**37**	100%

Statistics	Used ALEKS		Did NOT use ALEKS	
Distribution of Δ's	Students	Percent	Students	Percent
-4	0	0	0	0
-3	0	0	0	0
-2	0	0	0	0
-1	0	0	0	0
0	17	32%	21	57%
1	23	43%	15	41%
2	12	23%	1	3%
3	1	2%	0	0
4	0	0	0	0
Total	**53**	100%	**37**	100%

Probability	Used ALEKS		Did NOT use ALEKS	
Distribution of Δ's	Students	Percent	Students	Percent
-4	0	0	0	0
-3	0	0	0	0
-2	0	0	0	0
-1	1	2%	0	0
0	17	32%	28	76%
1	19	36%	9	24%
2	15	28%	0	0
3	1	2%	0	0
4	0	0	0	0
Total	**53**	100%	**37**	100%

Calculus Distribution of Δ's	Used Budnick Textbook		Did NOT use Budnick Textbook	
	Students	Percent	Students	Percent
-4	0	0	0	0
-3	0	0	0	0
-2	0	0	0	0
-1	0	0	0	0
0	16	29%	19	54%
1	20	36%	13	37%
2	17	31%	2	6%
3	2	4%	1	3%
4	0	0	0	0
Total	**55**	100%	**35**	100%

APPENDIX F: LBJ SCHOOL MATH TA INTERVIEW QUESTIONS

1. How would you describe the overall success of offering math TA sessions at the LBJ School this semester?
2. What are your general takeaways from the experience?
3. How would you improve or change the program moving forward?
4. What did you enjoy about serving in this role?
5. What was frustrating about serving in this role?
6. Please describe the type of math concepts attendees were looking for help on.
    a. Did questions seem to correlate to any specific math subject (e.g. algebra, calculus, statistics) or quantitative course (e.g. IEM, microeconomics, finance)?
7. How many different students would you estimate attended a session at least once throughout the semester?
    a. How many students were repeat attendees?
    b. Did you see the same students often, or a mix of different students?
8. What core quantitative professors did you have at the LBJ School?
9. Is there anything you would like to add that we haven't touched on?

APPENDIX G: LBJ SCHOOL MATH TA INTERVIEW SUMMARY

General Feedback

Erick described the program as "very helpful and successful" for students who attended the review sessions or tutoring hours. But he felt that students did not access this resource enough and attendance was not as high as it should have been based on the need he had personally witnessed among his fellow students during his time at LBJ.

Erick emphasized his perception that students tend to be reactive, not proactive. Students will seek out help if and when they need it, but they are unlikely to proactively volunteer their time unless they know they definitely need help (especially given how busy graduate students are). A few adjustments to the program should be made with this in mind.

Notable Quotes

> "People don't come to the review sessions because they love math. They come because they hate math and they really need the help because they feel under pressure."
>
> "Students aren't thinking about the tools they need to solve future problems, but simply what they need to know in order to solve a problem they are being graded on now."

Friday Review Sessions

What did attendance look like?

- Only 2-3 students came often - they had difficulty in general with math
- One student came to almost every session
- Students taking Pat Wong's class (Micro or IEM) were the most "loyal" attendees

Tutoring Hours

What did attendance look like?

- Student attendees were random
- People came for particular issues
- Average time per student was 30 min (range: 20 min to 60 max)
- Erick would use the extra time during tutoring hours to prepare for Friday review sessions

Recommendations for Improving the Program

1. Change the language used to announce/market the program
    a. In communications to students, the language indicated that "only math questions" were allowed. Erick felt that putting parameters on the program

created a barrier and prevented some students from using his services because they were unsure exactly what they could ask him.
   b. Erick recommends, in the future, that the TA should be the one to clarify what he or she can or cannot help with on a case-by-case basis.

2. Change the TA appointment - reduce total weekly hours
   a. Erick felt it was good to be available to students throughout the week (through the tutoring hours), but 10 hours per week was excessive for the volume of students actually attending.
   b. He recommends reducing the number of tutoring "walk-in" hours from 10 down to 4-6 per week with the additional option for students to set up an appointment via email or through OSAA.
   c. Weekly review sessions should be 1 hour per week and the TA should budget for 3-4 hours per week to prepare.
   d. Keep tutoring hours on Friday immediately following the review session so follow-up questions. These were the most well-attended tutoring hours each week.

3. Keep the review session content but change the scheduling
   a. The topics covered at the review sessions were appropriate. Most of them were planned by faculty based on what students would need to know for the quantitative core courses.
   b. However, Erick felt that the timing of each topic was off, which may have contributed to low student turnout.
   c. Put topics in an order where students have already covered the review session topic in class, felt lost, and are incentivized to seek help on that topic in order to be successful on an upcoming problem set or exam.

4. Change the language on the TA job posting
   a. The job posting should clearly outline the topical knowledge base and expectations for the role.
   b. Erick was confused by the difference between "math" and "statistics" - he had a strong background in math (i.e. functions, equations, algebra, and calculus) but his only exposure to statistics was in his IEM course. He spent a lot of time reviewing and studying statistics concepts (i.e. probability distributions, hypothesis testing, etc.) in order to help students in this area.

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